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EDITORIAL NOTES

Attention is directed to a review in this number of a valuable little book, *The Study of the Soil in the Field*, by G. R. Clarke, of the School of Rural Economy, Oxford, which has recently been published. Within the limits of its size it is a comprehensive little book, but what is at least equally important, and certainly more unusual, it is also comprehensible.

It is a new departure in the literature of the soil, in that it drives the soil student out of doors for his material, and in doing so (though we trust that this will not deter anyone from buying the book) compels him to work hard for it.

The viewpoint is the modern one, that soils should be studied in the first place by what they are in nature, without too much preoccupation with how best to employ them as industrial material. Of how essentially practical this outlook is, the book itself is a demonstration.

We cannot all be pedologists and specialize in the study of soils in well-equipped laboratories, but there can be few agriculturists to whom some knowledge of the soil in the field is not essential, and but few who have not, at times, felt the need of exactly such a book as this.

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INSECT PESTS AND CLIMATE.

In the Editorial Notes in the issue of last May it was stated that selected groups of the memoranda submitted to the Agricultural Research Conference held during the preceding February would be edited for publication in this Journal.

In the case of one of the subjects discussed, namely, the relation of climate to

the incidence of the major pests and diseases in the several territories, the Conference definitely recommended such publication of the memoranda, after each had been referred to its author for revision.

Unfortunately, the majority of the authors have indicated their unwillingness to allow the memoranda to be published, and it is therefore not possible to produce a symposium of the papers submitted to the Conference on this subject.

We print, however, in this number an interesting, if speculative, paper on the relation of climate to the coffee mealy bug of Kenya. We also call attention to an opinion of the Conference that "a considerable volume of information [on the relation of climate to pests and diseases] existed in the form of notes made by agriculturists which could usefully be published in the *East African Agricultural Journal*, and we invite anyone who is in possession of such notes to submit them.

PLANT BREEDING IN THE EMPIRE.

A comprehensive survey of the work in progress on plant breeding and related subjects in connection with crop improvement which is being carried out in the British Empire is made in Supplement II to Plant Breeding Abstracts, published by the Imperial Bureau of Plant Genetics, Cambridge (5/-). The summaries have been compiled from annual reports of Departments of Agriculture and other bodies concerned with agricultural research, covering the period 1932-1935.

Practically the whole range of economic plants, with the exception of herbage plants, is covered, and the supplement is so arranged that the work on any crop in any given country can easily be found.

To anyone in East Africa who is not addicted to reading annual reports, the scope of the work being carried out in the East African territories is probably not generally known. Cereal crops on which breeding or selection is being undertaken include wheat, maize, millets, sorghum and rice. Groundnuts, sesame, cowpeas, pigeon peas, soya beans, bean and peas are also receiving attention, the two latter for fodder and also for the canning industry. It is interesting to learn that in certain districts of Kenya variety trials are being conducted with carrots, asparagus, spinach and tomatoes, with the object of finding suitable varieties for canning.

Efforts are also being made in Kenya to breed high-yielding strains of pyrethrum. Coffee and cotton, sisal, tobacco, cassava, cloves, and even castor oil in Uganda and onions in Kenya are subjected to selection and the arts of the plant breeder.

This supplement is a valuable work of reference for the plant breeder, and gives information of great interest to anyone interested in the application of plant breeding methods for the improvement of agriculture generally.

A similar supplement is in process of compilation from the reports received from foreign stations.

VEGETATIVE PROPAGATION OF TROPICAL AND SUB-TROPICAL FRUITS.

Another recent publication emanating from the Imperial Agricultural Bureaux, which will be found to be of considerable interest both to agricultural officers and farmers in East Africa, is Technical Communication No. 7 of the Imperial Bureau of Fruit Production, East Malling (2/-).

This bulletin, compiled by G. St. Clair Feilden, is a comprehensive and standard work of reference on the vegetative propagation of tropical and sub-tropical fruits, of which over 90 species are dealt with.

A section, written by R. J. Garner, describes, with the help of illustrations, each type of budding, grafting or other vegetative propagation method mentioned as being suitable for dicotyledonous plants.

We quote the following from the foreword by Sir Geoffrey Evans, Director of the Imperial College of Tropical Agriculture, Trinidad:—

"The use of vegetative propagation methods would appear to be one of the surest signs of advanced horticulture, and has naturally reached its greatest developments in the temperate regions, probably because the question of improving quality in fruits has occupied the attention of numerous scientific workers for many generations, and in many cases has years of tradition behind it. The tropics, and particularly the wet tropics, have lagged behind, partly because scientific workers have, until the last decade or so, been few and far between, and also because local markets for high quality fruit have been strictly limited. With the development of low temperature research, problems of transport and storage are being solved, with the result that the vast markets of the industrial areas of the temperate zone may now become opened up, and it may be possible to place tropical fruits in these areas at a reasonable cost and with a minimum amount of loss through wastage. People travel about much more than they used to do, and, having visited the tropics and tasted some of its delectable fruits, they demand to be supplied with them when they return to their homes. The most obvious example is the banana, which fifty years ago was a comparatively expensive delicacy outside the tropics, but is now regarded as a regular article of diet in almost any town in Europe or North America. A most recent example is the grapefruit, which has achieved an immense popularity within the last twenty-five years. Other tropical fruits are beginning to be better known, such as the mango and even the pawpaw, whilst the avocado pear has a definite vogue, particularly in Northern America. Considerable progress in solving the transport problems of these fruits has been recorded in the past three or four years.

"It is obvious that, as markets expand, the demand for standard varieties of high quality will arise, and every effort must be made to supply plants of the required type for the new orchards that will be planted. It is in this connection that vegetative propagation methods are so important.

"In the temperate, and to a great extent also in the sub-tropical, areas chance variations or mutations have been selected and have been preserved and accumulated by means of vegetative methods by skilled gardeners for many decades past. In the wet tropics, by contrast, many species of fruit are as yet hardly removed from the wild state, and for this state of affairs seedling reproduction is mainly responsible. The tropical horticulturist of the present day is trying to make up for lost time, and is endeavouring to compress into a few years processes that have taken the accumulated experience of generations in the temperate zones. His task would be a pretty hopeless one under the old conditions when knowledge diffused slowly from one worker to another. Nowadays, much knowledge has been recorded and collated, but even so, as our experience at the Imperial College in Trinidad has shown, the technique of vegetative propagation remains very much a matter of trial and error. Under these conditions, the work of the Imperial Bureau of Fruit Production in summarizing and circulating the latest information from every part of the world is a most valuable contribution to the advancement of horticultural science in the tropics. It is particularly gratifying to note that a further memoir dealing with the vegetative propagation of perennial tropical and sub-tropical crops other than fruit will follow, because these crops, on account of their relatively low price compared with fruits, present peculiar difficulties. Rapid and cheap method of propagation will therefore have to be developed, if it is to become possible to adopt improvements of this kind on a large scale."

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The Annual Report of the Department of Agriculture, Tanganyika Territory,

1935 (Government Printer, Dar es Salaam, Sh. 4), is, as usual, full of interesting matter, only a few aspects of which can be touched on here.

During the year there was no place in which famine conditions prevailed. The recent campaign for planting subterranean food crops, such as cassava and sweet potatoes, has been a good insurance against famine; if, as is both probable and to be hoped, there are no serious invasions of locusts during the next few years, it is nevertheless desirable that this form of insurance should not be relaxed.

In the Director's review of the year it is stated that there is no doubt that the "Plant More Crops" campaign has resulted in a higher and happier standard of living for the peasant cultivator, and in addition has had considerable educative value.

The improvement in, and, up to the present, reasonable stability of sisal prices has given a much-needed fillip to that industry. But well over ninety per cent of the Territory's non-native agriculture is still on a one-crop basis, which is clearly not an ideal state of affairs. There is, however, a growing tendency for planters to adopt more diversified farming methods.

Tinned meats and fruits are now prepared for the local markets. (We have tried some of these and found them excellent, but it appears that they are not so readily obtainable as they should be. Some shops only stock an imported article, when a similar, equally good, and in most cases cheaper one, is prepared in the Territory. This also seems to be true, though perhaps less frequently, of Kenya produce.)

Tanganyika is fortunate in having a number of experimental stations in different parts of the country. The Coffee Research Station at Lyamungu is now well established on a sound basis, and its second annual report (pp. 77-115) will repay the perusal of all coffee planters in East Africa. The Sisal Experimental Station at Mlingano, near Tanga, is a year younger than this, but steady progress has been made with its development, and it will not be long before results of value should be forthcoming from the experiments laid down.

At Iheme there is an experimental station concerned mainly with trials and selection of tobacco and wheat.

At Morogoro, Lubaga, Mpanganya and Ukiriguru there are district stations occupied principally with the improvement of native crops and educational work.

Of particular interest, at the last-named station, is the progress made with the "Ideal Native Holdings", the number of volunteers for which has increased from an original three in 1933 to over two hundred.

Review

THE STUDY OF THE SOIL IN THE FIELD, G. R. Clarke: Oxford, Clarendon Press, 1936; 140 pp., 5/-.

This excellent and readable little book tells how to look with a seeing eye at a soil in the field. Its appearance is timely, for soil science has been readjusting itself in recent years towards occupying its due place as a department of natural history, yet the textbooks tend to daunt the inquiring layman by their inevitable emphasis on laboratory complexities. To those professing the subject the requirements of a good field description of a soil in regard to its profile characters and its relationship to relief, parent rocks, region-

al and local drainages, vegetation types and effects of human occupation, are nowadays becoming familiar, though there will be few amongst us who are not reminded by this book of some morphological feature or genetic factor to which we ought to pay more attention when gathering our material out of doors. But to the many who are concerned with soil without being specialists in it, and who would be prepared, if they knew how, to participate in its study as field observers, these things are not familiar. In fact, the possibilities that the subject holds, beyond the lore that every good farmer acquires on his own land, are to the majority quite unsuspected. No pedological Gilbert White, no Alfred Russel Wallace or W. H. Hudson of the mere earth, no Darwin since the classic on *Vegetable Mould*, has arisen to make the reading public soil-conscious. It has not occurred to the British Museum that it should collect and exhibit soil specimens or foster knowledge of the world's soils by equipping expeditions. The Royal Geographical Society's well-known *Hints to Travellers*, a highly expert, two-volume work of 800 pages, contains but one paragraph on the observation of soil (and that in the chapter on Industry and Commerce). Editors of Colonial Handbooks ignore the subject, though they concede space to long lists of butterflies. Towards remedying this neglect, none has done more in the last few years than the Oxford school of which Mr. G. R. Clarke is a member, and it is fitting that, to his work under Morison for the establishment in that University of a pioneer museum of soil monoliths, he has added the writing of the first work in English to which the outdoor soil student can turn for detailed guidance.

The book slips easily into the pocket, but manages to include full and original discussion of all necessary items in a soil description. It should do much to standardize the meaning of terms (as, for instance, those applied to soil structure) that are often used rather vaguely. There is an excellent chapter on soil-site characteristics, which would bear expansion on similar lines in a future edition. Chapter II, The Soil Profile Pit, is an exposition of the modern subject of soil morphology, but like Mr. Wackford Squeers a century ago, Clarke believes in personal labour on the soil as an aid to understanding principles: "Every soil-surveyor his own pit-digger" is his uncompromising counsel, for if you employ a slave to do the work for you, you miss a great deal in the handling qualities of your material. There are two concluding sections on soil mapping and on the methods of current regional surveys in Europe and America. The least satisfactory chapter is that on soil sampling, for the only method described is the rather specialized one used for museum monoliths, whereas there are many occasions when material must be collected, or the soil probed, by other means and other tools. On a point of detail, criticism may be offered of the adoption of the term "constitution" to describe what is usually understood as "consistence"; "constitution" would be better reserved for the nature of the clay-substance, knowledge of which is a laboratory rather than a field result.

I should like to see this book have a wide circulation; it might well be made an official issue to all field officers of Agricultural, Forestry, Veterinary and Geological Departments, and there will be many private occupiers of land who will find that it opens up a new source of interest which will have a profitable side in the better understanding of their soils.

G. MILNE.

Coffee Investigational Work

The Report of the Senior Coffee Officer, Kenya, for 1935

The rainfall recorded at the Scott Agricultural Laboratories for the year was 36.20 inches. This is an increase of 10.88 inches over the previous year, and 2.49 inches below the average for the past ten years.

1.—PRUNING.

Monthly Pruning.—The object of this work is to make observations on the influence of pruning on flowering. The plot consists of 34 rows, of which two rows are pruned each month. The first cycle of pruning, which was commenced in October, 1933, consisted of heavy cutting back in order to have all the trees producing a similar type of growth. The subsequent principle adopted is shortening the primaries by removing all weak and whippy wood and carrying out handling when necessary.

Although the rainfall conditions have not been satisfactory, an attempt has been made to draw some conclusions for the year under review. The October, November and December plots flowered in the short rains of 1934, the biggest flowering taking place on the 12th December. The January and February plots produced a small flowering on the same date, but the main flowering did not occur until February, 1935, during which month the March and April plots also produced a heavy flowering. In the May, June, July and August plots, occasional branches produced a very small flowering in February, but the main flowering was not recorded until the 28th October, 1935, and some two weeks later the September plot burst into flower. The October, November and December plots bore the heaviest crop, and showed much more distress prior to and during the picking season. The January, February and March plots also bore heavily, the March one slightly more than the other two, but these plots did not show the same effects from drought conditions as those previously mentioned.

It must be pointed out that, after pruning, the more advanced wood remaining on the bushes will flower either in the short or the long rains or be responsible for intermittent flowerings. This latter condition, together with the risk of over-cropping, can, however, be lessened considerably if more care is exercised during handling. The main object of this operation is to strike a balance between excessive and insufficient wood, and also to select and retain, as far as possible, such wood as will flower in the short or long rains as required. In this respect, it will be noticed during handling that certain wood promises to flower in the wrong season; this wood should be removed. It would appear that the months of June and July are the most suitable periods for this selection, and at this time it is also possible to regulate crop if necessary by the removal of a certain amount of bearing secondaries and tertiaries.

The above is the ideal for which planters should aim, but it is realized that too often labour conditions will interfere and prevent handling at the most advantageous time.

Pruning Single-stem Trees.—For some years planters have adopted a policy of very severe cutting back, which tends to force the tree to produce a crop in excess of its capacity, thus resulting in biennial bearing. A plot treated in this manner at the Scott Laboratories produced a crop of approximately one ton of

coffee per acre in 1934. At the end of the season the bushes were in a state of debility and failed to produce any crop during the following season. This method of treatment of coffee trees appears to be on the increase, and is to be strongly condemned. It stands to reason that, if quantity is produced in excess of the capacity of the plant, quality must be affected, and the fact that biennial bearing is brought about should in itself be a deterrent against adopting the practice.

Multiple-stem Pruning.—The technique which has been carried out at the Scott Laboratories, and which has been found highly satisfactory, is described below.

After the crop has been harvested, all primaries that have borne two crops will have developed a drooping habit, a distinct gap being noticeable between them and those that have only borne one crop. All such drooping primaries are then removed. It has been found that, under our conditions, the primaries that are allowed to remain are situated on the top three or four feet of the main stem. Many planters adopt a principle of a specific measure for the wood allowed to remain; this appears to very satisfactory, for it usually coincides with the primaries situated above the gap just referred to.

At the time of pruning, excessive growth of secondaries and tertiaries should be removed, and the handling operation again repeated in the month of June. If it is realized that in this system of pruning the crop is chiefly produced on primaries, and not on secondaries and tertiaries, it will be understood that it is not necessary to exercise the same care in handling as in the single-stem system.

By adopting the multiple-stem system, crops can be more easily regulated than on the single-stem; it is estimated that the cost of pruning the former is one-fourth or one-fifth of that of the latter.

While handling is not so exacting on multiple as on single stem, it must not, however, be neglected; there is a tendency to neglect this work, particularly on heads of old verticals. The results of experiments carried out on coffee kindly supplied by a planter give an indication of the benefits derived from judicious handling. This experiment consisted of a comparison between handled suckers *versus* old unhandled heads.

	Handled	Un-handled
Weight of cherry ..	734 lb.	708 lb.
No. of debis of clean cherry per ton ..	446·6	471·1
Weight of clean coffee, all grades	120 lb. 6oz.	114 lb. ½oz.
No. of lb. of cherry to 1 lb. clean	6·1	6·43
Seconds eliminated in washing channel ..	5·8 lb.	9·8 lb.
GRADES	*lb. oz.*	*lb. oz.*
Elephants and oversize	1 13½	1½
Pea-berry	3 3½	2 2
A	41 ½	25 6½
B	55 15¾	55 6½
C	17 11¾	30 14½
T	9¼	1½
	120 6¼	114 ½

The liquoring reports stated that the coffee from the handled verticals was bolder, heavier, and had a stronger liquor than that from the unhandled, and was valued at £5 per ton more. From a study of the higher percentage of better grades, together with the higher valuation it would seem obvious that handling is not only essential but economic.

In addition to the above experiment, and in order to disprove wild statements that have been made from time to time to the effect that coffee grown on the

multiple stem is often inferior in quality to that produced on single stem, comparisons were made during the year with the following results:—

Liquoring Test and Liquorer's Remarks.

Multiple Stem: Total points gained, 20½.—Bold beans, well made and fat; hardish roast, slight desirable reddish tinge; fully Sh. 12 per cwt. difference between the ungraded multiple and the sample of single stem and a minimum of Sh. 20 per cwt. on the Grade A of the two samples.

Single Stem: Total points gained, 14½.—Rather speckled in appearance, with a tendency to a brownish colour; very mixed, with many semi-pales; not nearly such an attractive coffee as that grown on the multiple stem.

The treatment of the two coffees during preparation was identical. It may be added that the above results confirm those of previous years.

Another interesting observation was made in regard to a mottled condition of the cherry, prevalent throughout the country during the year. This condition was severe at this station, but only on coffee grown on single-stem trees; the multiple-stem trees were not affected. A test was carried out by the Chemical Section in order to ascertain the respective moisture content of ripe mottled cherries and unmottled from the multiple-stem trees. This gave a result of 64.2 per cent in the former and 66.2 per cent in the latter.

Further observations on multiple-stem trees reveal the fact that the incidence of *Antestia* is less than on single stem in good leafage; also that multiple-stem trees as treated at the Scott Laboratories show less effect of drought than single-stem trees.

The average yields over a period of six years (the present year being excluded because stripping may have affected the results) are: Single stem, 6.26 cwt. per acre; multiple stem, 6.60 cwt. per acre.

2.—BORDEAUX SPRAYING.

Bordeaux spraying experiments for the control of leaf fall have been continued during the year. The results of this experiment, as detailed below, again prove conclusively the benefits to be derived from adopting spraying as a routine practice.

Plot I: Bordeaux spray 1 per cent; one spraying annually in March.—The trees, during the period when they were subjected to a heavy strain through the maturing of the crop under drought conditions, showed good dark healthy leafage, no dieback, and they bore a reasonable crop.

Plot II: Bordeaux spray 1 per cent; two sprayings annually in March and June.—The leafage was dark and healthy and even heavier in this plot than in Plot I. The crop was approximately the same as in Plot I.

Plot III: Bordeaux spray ½ per cent; two sprayings annually in March and June.—In appearance there was little to choose between this and Plot I. It had possibly slightly more leafage, in spite of bearing the heaviest crop throughout the whole experiment.

Plot IV: Bordeaux spray ½ per cent; one spraying annually in March.—This block had a good leafage but was of a rather lighter green in colour. Wood growth appeared slightly more whippy than in any of the other sprayed plots.

Plot V: Control Plot.—The plot towards the latter part of 1934 showed considerable dieback and general debility, due to cropping beyond the capacity of the trees and to the climatic conditions

prevailing. During the year under review the trees made good but slow recovery, primarily due to the fact that little or no crop was borne.

The growth was definitely more whippy than in any of the sprayed blocks, and heavy leaf fall occurred in 1935, although the trees were bearing little strain.

YIELDS OF COFFEE FROM SPRAYING EXPERIMENT USING COPPER SULPHATE NEUTRALIZED WITH CALCIUM CARBIDE

No. of Sprayings Per Annum	Strength of Spray	CWT. PER ACRE		
		1934–5	1935–6	Average
	Per cent			
1 ..	1	5·78	6·3	6·04
2 ..	1	5·7	5·99	5·84
1 ..	½	6·50	6·13	6·31
2 ..	½	6·46	10·61	8·53
Control Plot ..	—	3·6	2·05	2·82

It would be premature to differentiate between the various spray treatments, but it is significant that all sprayed plots gave over one hundred per cent increase in yields over the control plot.

Representative samples of the sprayed and unsprayed coffee were prepared for liquoring tests, the following results being obtained:—

> Sprayed one per cent was the best, closely followed by that sprayed with half per cent; the control was definitely the worst. The main points of difference noted were in the quality and intensity of acidity, and body and character.

From these results it would appear that Bordeaux spray applied as recommended has no detrimental effects on quality, but, on the contrary, produces a decided superiority.

3.—COFFEE VARIETIES AND LOCAL SELECTIONS.

A variety known as "Amfillo" was introduced during the year from Abyssinia. This is now on trial at these Laboratories, and small quantities of seed have been distributed to selected areas in the Colony. Two previous attempts were made to establish this coffee, but on each occasion the seed failed to germinate. The following are the details of the variety in its natural habitat:—

Country of origin.—Western Abyssinia.

District.—Amfillo.

Altitude.—6,500 feet, on slopes of Tulu Walel Mountain.

Rainfall.—83 inches per annum.

Cultivation.—Although this coffee is harvested and exported, it grows under natural conditions, no cultivation being attempted.

Harar.—An Eastern Abyssinian importation from the district of Harar, this coffee is now six years old, and is again worthy of special mention. For the past three seasons, although bearing a heavy crop each season, it has stood up to drought conditions in a remarkable manner and, with one exception, was the only variety on which early stripping was not carried out. In view of its apparent drought-resisting characteristics, together with heavy bearing propensities and good liquoring reports, it is now considered that the variety can be recommended, more particularly in the drier belts.

The Department of Agriculture has endeavoured to obtain seed in bulk from Harar, but unfortunately, owing to the Italo-Abyssinian war, without result as yet.

Harar is also on trial on many plantations west of the Rift Valley, but nothing

yet is known in regard to its resistance to Elgon dieback and coffee berry disease. At three years old, however, on Elgon, the growth is good and it would appear to be resistant to cold.

The liquoring report on Harar as received from London reads as follows:—

> "Great possibilities. Good culture and preparation has made an almost hitherto unmarketable coffee into a really fine one."

Series A.—Selections of the second generation of this type have been made. These, consisting of five trees, have been selfed during the year for further individual tree propagation.

In regard to the high proportion of elephant beans that occurred in the initial stages of selection, the result of the work to date shows that this fault can be greatly reduced if seed is taken from parent trees producing only a small percentage of these beans.

Series B.—This selection, unlike Series A, appears to be breeding very true to type from seed. This type closely resembles Harar in characteristics and habits.

Blue Mountain, Guatemala, Columbaris and Padang.—These closely resemble each other in their habit of growth. From observations to date, they are not varieties suited to dry conditions.

Bourbon.—Grown from imported seed, this resembles what is known here as Mocha. As the trees are still comparatively young, no samples have yet been submitted for a general report.

Mysore.—This variety shows some resemblance to Blue Mountain and Guatemala, but the growth under the conditions here is more vigorous.

In addition to imported varieties and the selections mentioned above, a wide range of selections has been established from parents showing outstanding individual characteristics.

4.—Manurial Experiment.

The object of this experiment is (*a*) to note the effect of balanced and unbalanced manuring upon the growth and quality of coffee; (*b*) to ascertain the relative weights of cherry, parchment, and hulled coffee.

The experiment was begun in the long rains of 1932 in a block of coffee that had been planted in the short rains of 1929. Owing to limited space, it is unfortunate that, like many other experiments laid down at this station, the treatment can only be carried out in single plots, but it is useful for observation.

The various treatments adopted were: N+P+K; N+P; N+K; K+P; K+P+Lime; K+P+Legume; K+P+Non-legume; Compost; Control.

The compost and N+P+K plots are significantly better than the others, the outstanding plot being the former. There is no significant difference between the remainder of the plots, including the control.

The following is a summary of the liquoring reports for the years 1934 and 1935:—

Report I.—1934

Sample	Liquor			
	Acidity			
	Quality	Intensity	Body and Character	Total
Control	1	1	2	4
Compost	3	2	2	7
K+P+legume ..	2	1	2	5
N+P+K ..	1	1	1	3
K+P+non-legume	3	2	2	7
K+P	1	1	1	3
K+P+lime ..	1	1½	1	3½
N+K	2	1	2	5
N+P	2	1	2	5

The liquorer stated that if prices were being allotted there would be about £6 per ton difference between the best and the worst of the series. The best was stated to be compost and K+P+non-legume, as is shown by the table, while the worst was said to be the control, although it will be noticed that it gained more points than N+P+K or K+P or K+P+lime.

Report 2.

The following is the order of preference given by another liquorer on identical samples, but after the coffee had been kept for approximately three months:—

Compost .. .. Definitely best.
K+P+lime .. Close second.
N+K
P+K.. .. .. } Very close to N+K.
N+P.. .. .. }
Control }
N+P+K }
K+P+legume }
K+P+non-legume }

The report agrees with the previous one in that compost is placed first, but this is rather offset by the fact that K+P+non-legume, which in Report 1 gained the same points as compost, is here found at the bottom of the list.

1935.

Liquorer's Comments.—Raws were practically identical in colour and size.

Roasts were classified in the following order in respect of boldness:—

N+P+K: Boldest.
Control: Close second.
N+P, P+K, K+P+non-legume.
K+P+lime, K+P+legume.
N+K, Compost: Smallest.

As regards liquors, N+P and P+K were the best, while the worst two were N+K and compost. All the others were practically identical with each other, and intermediate between the extremes. But the whole difference was so slight throughout the series that the liquorer stated that if prices were being allotted there would be no difference whatever between the whole range.

As Dr. Case, Biochemist to the Coffee Board, remarks, "It would be rash to claim that any positive conclusions whatever can be drawn from these results so far."

5.—MULCHING.

It has been stated that mulching has a decided effect on lessening the incidence of *Pheidole punctulata*, the ant attendant on mealy bug, and in order to observe if such was the case a plot was mulched in 1932. Since the experiment was laid down mealy bug has been very much on the decrease, and therefore no conclusions of any material value could be noted, but the beneficial effect on the coffee bushes in the mulched plot, in comparison with the control plot, was most outstanding.

From observations made on mulching in various districts, the practice can be thoroughly recommended. Where it has been carried out continuously for several years, the texture of the soil has been completely changed, and bushes bearing heavily have carried their crop well, whereas heavy bearing trees on unmulched areas have suffered severely from yellowing and dieback.

The cost of mulching, based on figures supplied by planters, varies from Sh. 8 to Sh. 23 per acre. The latter figure is much too high, and can be reduced considerably if steps are taken to grow material, such as elephant grass, in close proximity to the coffee *shambas*.

Economic organization is also required during the mulching operation. In this respect it is not economic to carry the material long distances in the rows of coffee, and it is suggested that two hundred feet from the headland should be the maximum.

In plantations with large acreages of coffee it is realized that continuous mulching may be impracticable owing to limited material. As a compromise, it will be found satisfactory to mulch alternate rows each season.

This has the advantage that the risk of fire is minimized owing to the two unmulched rows acting as a firebreak.

In the wetter districts mulching may not be necessary from the point of view of moisture conservation, but its use, if applied at varying intervals according to the slope of the land will, in conjunction with soil erosion measures, be found most satisfactory.

While no yield records are available to support the pros and cons of mulching, observations made in the field on the beneficial effects on the trees provide sufficient evidence to justify recommending the practice. It is considered that if coffee is to be grown successfully in areas that are subjected to long spells of drought conditions, due to unevenly distributed rainfall, mulching must be adopted as a general routine practice.

6.—Shade.

A wide selection of possibly suitable shade trees is being grown at these Laboratories with a view to studying their growth and for demonstrating to planters the treatment of individual trees for shade regulation. In addition to the trees under trial which have been mentioned in previous reports, there must be added the Giant Castor. The seed of this was obtained from Commander Phillpott, Turbo, who introduced it from Uganda. It is only a temporary shade, but it is hoped it will supersede the local varieties which have been grown in the past, and which are considered quite unsuitable as temporary shade trees.

7.—Planting Out of Seedlings.

The results of experiments that were laid down some years ago on the effect of planting out seedlings in different sized holes are now beginning to materialize. The outstanding method would appear to be the adoption of large-sized holes, approximately four feet in diameter and two feet deep. A *kerai* of compost was thoroughly incorporated with the soil when filling in the holes, and the result on the trees is most marked in comparison with smaller holes, either manured or not. It should be emphasized that, particularly in large holes, the filling in should take place sufficiently early to allow for complete settling of the soil prior to planting.

8.—Summary of Results of Liquoring Tests and Fermentation Experiments.

Liquoring tests with multiple and single stem, with spraying experiments, and manurial trials, have already been dealt with in this report, but in addition to these the following may be of interest:

Pulping Experiment.

	Points Awarded.
Coffee pulped immediately after picking	15
Coffee soaked in water for 18 hours before pulping	14
Coffee stored dry for 18 hours before pulping	15
Coffee soaked in water for 42 hours before pulping	17½

The liquorer stated that the last sample was easily the best, with a good roast, generally hardish, but inclined to dullness.

Various periods of fermentation, under water and dry.

Experiment 1.

Order of placing by Liquorer.

(1) 240 hours under water fermentation.
(2) 72 hours under water fermentation.
(3) 48 hours dry fermentation.
(4) 96 hours under water fermentation.
240 hours dry fermentation.
36 hours dry fermentation.

(5) 18 hours under water fermentation.
30 hours under water fermentation.
72 hours dry fermentation.
(6) 48 hours under water fermentation.
(7) 18 hours dry fermentation.
96 hours dry fermentation.
(8) 36 hours under water fermentation.
30 hours dry fermentation.

Experiment 2.

(The above experiment was repeated, but consisting of four samples in each series from 48 hours to 240 hours.)

Order of placing by Liquorer.

(1) 96 hours dry fermentation.
(2) 96 hours under water fermentation.
240 hours under water fermentation.
(3) 48 hours under water fermentation.
240 hours dry fermentation.
(4) 72 hours under water fermentation.
(5) 72 hours dry fermentation.
(6) 48 hours dry fermentation.

Because, however, of the slight differences between some of the coffees, it is impossible to make a definite statement in regard to the relative merits of the various treatments.

Comparison of coffee from over-ripe, ripe, and under-ripe cherry.

	Points awarded.	Placing.
Over-ripe	18 ...	1
Ripe	12 ...	4
Under-ripe	17 ...	2
Mixture of the above ...	14 ...	3

During the preparation it was noted that the over-ripe cherry reached the washable stage approximately eight hours before the normal ripe, while the fermentation of the under-ripe was considerably slower. The results are not in accord with those of a similar experiment in the previous year, so that no conclusions can be drawn.

Sun-dried throughout day on barbecue versus *sun-dried on barbecue but heaped up at 3 p.m. each afternoon.*

In this experiment the ordinary sun-dried coffee was vastly superior, the coffee that had received the other treatment having a distinctive taint in the liquor. It was impossible to say where the taint originated, since both the coffees were dried on the same barbecue. Although the introduction of this outside factor negatives any results, it suggests the possibility of an appreciable tainting being caused by the unnoticed entry, perhaps wind blown, of some material into the heap.

Comparison of coffee sun-dried with that sun-dried from 9 a.m. to 11 a.m. and then placed under cover.

The principal object of this experiment was to prevent an undue amount of sun from cracking the parchment, thereby eliminating uneven drying and consequent uneven colour in the bean. In regard to the appearance in the raw, the ordinary sun-dried received 5½ points in comparison with 4 points for the second treatment. The roast and acidity were identical in both cases, and the superiority of the one treatment over the other was so slight that little can be inferred as to the relative merits of the treatments.

Under water fermentation versus *fermented dry for 24 hours, and completed under water* versus *fermented under water for 24 hours and completed dry.*

The placings in this experiment were as follows:—

1. Fermented 24 hours under water, completed dry, awarded 22½ points.
2. Under water fermentation, awarded 20 points.
3. Fermented 24 hours dry and completed under water, awarded 11½ points.

The difference between the extremes is most marked, and in comparison with all the coffees from other experiments the fermented 24 hours under water and completed dry, was the outstanding

coffee at the Scott Laboratories, both on appearance and quality.

It would seem that in this case one method had definitely affected quality, while the other method had hardly affected, if at all, the inherent qualities of the bean. It would be premature to make definite statements as yet, and the experiment will be repeated several times during the forthcoming season.

9.—VEGETATIVE PROPAGATION.

The year 1931 saw a start made with vegetative propagation at the Scott Agricultural Laboratories. The initial research was on the propagation of cuttings and the technique of budding and grafting.

It was soon apparent that coffee cuttings were comparatively difficult to root. Methods found suitable in other countries proved a failure. In spite of constant alterations to propagator design and trials with different mediums, only occasional cuttings rooted. The most serious menace to the successful propagation of cuttings proved to be the "damping off" fungus, and to combat this disease extremely cleanly conditions in the propagators were found to be essential. However, in spite of constant failures, technique was improved by experience, and certain cutting types revealed themselves as being more liable to root, the ideal being an etiolated sucker type usually found in the centre of the clustered growth of a stumped tree.

A certain measure of success was attained by rooting cuttings attached to a parent stump, the method being to select six to eight suckers on a tree stumped about 6 inches from ground level, and to ring-bark these near the point of union with the parent stump. Etiolated conditions are effected by placing round the suckers a *debi* with its ends removed and filled with soil. Rooting occurs after about four months, the extent depending on the weather conditions. This method of propagating cuttings is unsatisfactory, in that only a limited amount of material can be utilized on the parent; also there is a tendency for rooting to concentrate on one sucker to the apparent detriment of the others.

Based on experience gained during the previous four years, improved propagators were constructed in 1935. By the use of forest loam as the medium, very satisfactory results accrued; 70 per cent of the cuttings rooted.

Budding proved to be impracticable for several reasons, one of which was the difficulty to get the buds to "take".

From the start, cleft grafting in the nursery was successful, and, as a result, observational work of testing varieties as possible rootstocks was at once commenced. Of these rootstocks the following *C. arabica* varieties are under observation, each having Series A Kenya Selected as the scion, and observations are for comparison with seedling Series A:—

C. arabica var.—
- Columnaris;
- Blue Mountain;
- Maragogipe;
- Series E (Kenya Selected).
- Series J (Kenya Selected).
- Red Leafed Hybrid.
- Drought Resistant Selection.

Of varieties other than *C. arabica*, *C. eugenioides* and *C. robusta* are the only two at the moment under observation, but grafts are being made on the following, which will be planted out later:—
- *C. dybowskii;*
- *C. congensis;*
- *C. liberica;*
- *C. quillou;*
- *C. excelsa;*
- Bogor Prada Hybrid.

A collection of indigenous Rubiaceae is being made also for trial as prospective rootstocks.

Grafting under field conditions has proved difficult, but occasional successes show the necessity of continued work in this direction.

Crosses.—The following crosses were made during the year:—

Mocha x *C. eugenioides.*
Mysore x *C. eugenioides.*
Harar x *C. eugenioides.*
Harar x Iringa.
Blue Mountain x Mocha.
Mocha x Mysore.
Harar x Tight growth Mocha type.

The only failure was the Harar x *C. eugenioides,* and the remainder are at present in the nursery, but are too immature as yet for further comment.

Pest on Ramie

It has come to the notice of the Kenya Department of Agriculture that the larvæ (caterpillars) of the butterfly *Acraea esebria,* which normally live upon the indigenous plants of the natural order *Urticaceae,* have been found causing damage to ramie plants growing within the Colony.

Since ramie is a plant member of the natural order *Urticaceae,* it may be anticipated that the *Acraeas* will become a pest of ramie when extensive acreages of this plant are grown. The Department of Agriculture thus desires to bring to the notice of all growers of ramie the importance of keeping a sharp look-out for the appearance of this insect and of adopting control measures in the initial stages of attack.

The caterpillars are gregarious and, when young, will be found congregated together upon the under-surface of a single leaf. If observed in this stage the leaf, together with the caterpillars, can be taken off and destroyed.

As the caterpillars increase in size they have the habit of completely defoliating the plant before moving on to the next one.

These caterpillars can easily be collected by placing a sheet near to the attacked plant and vigorously shaking the plant, when it will be found that the caterpillars fall on to the sheet; or the plant may be bent over the sheet and tapped vigorously, thus dislodging the caterpillars.

Should the infestation become severe and either of the above methods found to be impracticable, then it will become necessary to spray with a stomach poison, and for this lead arsenate powder is recommended at the rate of 2½ lb. per 100 gallons of water.

The Raising and Growing of Trees in Kenya

By the Conservator of Forests and Staff of the Forest Department, Kenya.

These notes deal in a brief manner with the subject of tree planting in Kenya. The subject naturally falls into two parts:—

1. The raising of trees from seed in nurseries.
2. The establishment of plantations.

The two are separate subjects, and planters can, if they so wish, eliminate nursery work by buying plants direct from tree nurseries managed either by private individuals or the Forest Department.

Nursery Practice.

Situation of Nursery.

The site of a nursery is generally determined by the water supply. The site should be flattish, if possible, to save labour in construction. In warm localities it does not matter to any great extent if it is down in a river valley, provided it is safe from flooding. In higher altitudes, where there is danger of frost, the site should be well above the bottom of the valley, where cold air collects, and preferably on a ridge. In any case, it must be above the frost line, and in a position where free air circulation is obtained and there is no impediment to the drainage of cold air down hill. Nurseries immediately surrounded by plantations should be avoided, as the air is very liable to become stagnant. In this respect also, light fencing is preferable to thick hedges. Where possible, all large trees should be removed from the neighbourhood of the nursery. Shading is better done artificially, as the leaf drip from trees is harmful. Where sites near water are unsuitable for any of the above reasons, a water supply by means of a pump or ram to tanks in the nursery itself should be considered.

Lay-out of Nursery.

Nurseries should be laid out with straight beds, 3 feet wide, and divided by paths of a similar width. These beds conveniently hold two standard boxes, and are handy for watering. Beds into which plants are going to be lined out direct should be narrower, i.e. not more than 2 feet wide, to facilitate root pruning with *pangas*.

Beds should run east and west, to prevent as far as possible the morning and afternoon sun from beating in under the shade. In sloping, unterraced nurseries, where the beds run along the contour, they are apt to bank up the wash which leads to damage, and arrangements should be made for drainage through beds at frequent intervals. Sloping nurseries are often preferable to terraced ones, as being better drained, but the beds themselves must be quite level.

In making seed beds the lines should be trenched to a depth of one foot and the natural soil removed. Soil for use in seed beds and plant trays should be a mixture of loam and humus, with a basis of ordinary mineral top soil. The humus should be collected from the surface soil under trees or made in compost pits. Before using, it should be passed through a quarter-inch sieve on to a heap; a small crater should then be formed on the top of the mound and filled with water; soil and water should be well mixed, and the process repeated until all the soil is thoroughly wet. It is essential to see that this is done, as forest humus is almost waterproof, and if put dry on a seed bed will not allow rain or watering to penetrate. The humus, when soaked, may be mixed with some loamy mineral soil, put on to the bed, raked flat and firmed

down. The beds should be raised 4 to 6 inches above the level of the path to avoid waterlogging. They should be edged with split cedar, old shingles, poles or wattling to prevent the edges from being washed out.

Shades should be 2 ft. 6 in. to 3 ft. high, erected on durable posts, such as Muhugu, cedar, tree fern, etc. The shade should be split bamboo; grass goes mouldy, and is untidy, and papyrus mats do not permit of regulation of the shade. Branches of bushes are second best choice to bamboo. All main nurseries should have bamboos planted nearby.

Where rain is frequent while the shade is in use, one side may be built slightly higher than the other and the bamboos set groove uppermost; this will drain off some of the rain to the side, and minimize drip.

It is advisable to have posts one foot high, as well as three feet, so that in the early stages the shade may be low, thereby giving greater protection from the slanting rays of the sun. Later the whole shade may be raised to the upper level before final removal.

Seed should be sown thinly but evenly, and covered with a thin layer of finely sifted soil, and watered carefully with a fine rose.

The three essentials for optimum germination of seeds are air, a constant but moderate supply of water, and a temperature of between 55° and 75° F. The presence or absence of light is of no importance until the first leaves appear. To maintain the last two essentials in this country, with its hot sun and cold nights, shading with overhead shade or thatching the beds with grass is necessary. If white ants are numerous, grass thatching may be undesirable and may be replaced by empty plant trays laid on the bed. The cover must be raised off the ground the moment germination begins.

Care must be taken in watering to see that the soil is kept damp but neither too wet nor too dry. Excessive watering excludes the air from the soil.

The soil should be changed in the seed beds at least every two years.

When it is required to raise a large number of trees of one species for planting it should be remembered that all the seed should not be sown on one day, since this would result in all the seedlings being ready for pricking out at one moment. Sowing should be at intervals, spread over two or three weeks, so that the subsequent work of pricking out should also be spread out.

Pricking Out.

Seedlings in general are pricked out into boxes or lines in beds when they are about 1½ in. in height. This applies to the Eucalypts (except *Eucalyptus maculata* and *citriodora,* which should be pricked out when the first leaf shows), Cedar, Grevillea, the Cypresses, Olive (which also gives good results at 2½ in.), and Muhugu. Mueri stands pricking out at 3 to 4 in., also Muhuru, Muringa, and possibly Muchichio at 2 in. Mukeo stands pricking out at 1½ in. or when the second leaf shows, but it is better sown three to four months before being required for planting and taken straight from the seed bed without having been pricked out at all.

Boxes.

These are made of Cedar shingles, and hold 50 plants each. The two ends measure 16 in. x 4 in. x ¾ in., and the bottom and sides are composed of six shingles, 16 in. x 4 in. x ⅜ in. Before making up the boxes the shingles should be soaked in water to minimize splitting.

Oval brads, 1 in. long, are used, and the bottom slates of the box should be set slightly apart from each other to facilitate drainage. Shingles in which there is no white sapwood cost about Sh. 30 per 1,000 at local mills. These are most durable, but if complete durability is not required quotations of Sh. 25 can be obtained. Oval 1 in. brads cost locally 30 cents per lb., and 1 lb. will make about 35 boxes. They are filled with soil prepared similarly to that for seed beds. The seedlings, carefully lifted from the seed beds, are dibbled in 2 in. apart, under the cover of a potting shed. To facilitate spacing in the boxes a board which can fit into the top of the box is studded with nails the required distance apart, and the imprint of these in the soil gives the position of each hole. The holes for planting are made with a sharp, pointed stick. The soil must be well firmed down round the roots and at the bottom of the box, and the whole well watered on completion. Roots must be set straight and not curved, or the subsequent growth of the trees may be adversely affected. It is better to nip off the ends of long roots rather than risk their being doubled up. The boxes are kept in a shed for a week if possible, and then moved out into the beds under heavy shade. Watering once a day to begin with is generally enough, but must be increased to twice a day as the weather gets hotter and the seedling larger, with consequent increase in its demand for moisture. Watering should then be done morning and evening, but not in the heat of the day. It is necessary to make sure that the water is really penetrating the soil to the lowest roots of the plant. Morning is the time to water when there is danger of frost.

The shade should be decreased gradually over a period of one to two months, but as rapidly as possible so that the plants may become hardened off to full sunlight. Sometimes during very hot and dry weather shade may be increased temporarily to prevent evaporation and reduce watering.

Boxes should be continually lifted when the plants get big and the roots that have come through the bottom cut away; if this is not done they will grow into the soil below. One of the main advantages of boxes is that the tap root, by this method, can be checked and the laterals encouraged.

Nursery Lines.

Nursery lines are prepared in the same way as a seed bed, and the plants pricked out direct into them under heavy shade, which is gradually reduced in the ordinary way.

Any seedlings can be raised in nursery lines, and this is the usual practice in European countries. But the important point is whether they will transplant well into the plantation. When planted in boxes the boxes are taken to the actual site of planting, and the plants can be carved out one by one with a considerable ball of earth and little disturbance and exposure of the roots. With lines the plants, even if carefully lifted with a fork, lose most of the earth and are subject to considerable exposure in consequence. In temperate climates, with a long cool planting season, such plants may recover, but in Kenya ten days of wet weather may be followed by a similar period of scorching sun, and even the days of rain may have a few hours of hot sun. Box planting therefore has been found the safest and, in the long run, the cheapest method; planting in banana-leaf or other pots, though most efficient, is too expensive over large areas.

While in a really wet and prolonged planting season many species plant suc-

cessfully from lines, in an average season of patchy weather only Olive, the Cypresses, and sometimes Mukeo and Grevillea, have been found to plant out well from lines. These species should be the only ones normally not pricked into boxes, although of course for them boxes can be used if available.

Most species grow faster in nursery lines than in boxes.

If plants are raised in nursery lines it will probably be found advisable to root-prune them. In lines they tend to develop a long tap root, which cannot be checked as in boxes by scraping the bottom of the box. The usual method adopted is to pull away the sides of the raised beds or dig a trench along the side of lower beds, and then by pushing a sharp *panga* from each side horizontally 3 to 4 in. below the general level of the collars of the plants, and by a sawing motion to cut all the roots through. Heavy shading and watering is needed directly afterwards, and the operation should be carried out at least three weeks before planting begins. It is most important to see that the watering really reaches down to where the roots have been cut. The operation may be repeated if necessary. The result is to sever the tap root and to encourage growth of laterals. Species that will stand it should be cut back before root-pruning.

Where boxes are scarce, a suggestion that works quite well is that seedlings can be pricked out into squares, rather less than an actual box capacity, in lines. When boxes become available at the beginning of the season, these squares can be cut out bodily and put into boxes, and treated as newly pricked-out plants for a few days. Line seedlings can also be cut back, root-pruned and pricked out again into boxes as they become available. The former method is better, and worthy of adoption. Should the plants have grown rather large in the boxes before they can be planted out, greater success will be assured if cuts are made through the soil in the box, grid fashion, severing the roots, which will have become intertwined, about a fortnight to three weeks before planting. The boxes should be well watered after the operation. Each plant will then be standing in its own block of soil, and will have started to make new root growth by the time of planting, and will consequently be in ideal condition to take root in its new site.

Treatment of Plants before Planting.

If seed is sown at the right time, and planting rains are normal, the plants should be at their correct size when needed. It often happens, however, that plants get over-sized.

The following species will, under these circumstances, stand cutting back to 3 or 4 inches: Eucalypts, Mueri, Mukeo, *Acacia melanoxylon*, Muringa, Grevillea, Olive, and Mutati.

Pines, Cypress, Cedar, and most other indigenous species will not stand this treatment.

Cutting back has the following advantages:—

1. It reduces the size of over-sized plants.
2. It allows plants to be held over for a later rain.
3. It serves, in conjunction with root-pruning, to strengthen the root system and encourage lateral growth.
4. By decreasing leaf area, it tends to reduce transpiration and hence rapid desiccation of the tree after planting.
5. It decreases the chance of failures, but also retards height growth slightly for the first year.
6. Trees may be cut back more than once, but the final cutting should not be later than a month before planting.

It is always advisable when planting to nip off some of the leaves of broad-leaved species to reduce transpiration. This is particularly possible with gums.

The general size of plants suitable for planting out into the plantations is 6 to 8 in. high. The age of such plants for different species varies with different districts.

The essentials for a healthy plant are:

1. That it should not be too small; 6 in. is a minimum height as an average.
2. That it should have a good root system.
3. That is should not be lanky but bushy.

In swamp planting, the bigger the trees the better.

Generally speaking, indigenous species take 9 to 13 months from seed to planting size, and exotics 6 to 9 months.

The following table gives general information on the subject for the commoner trees:—

Species	Average No. of Plants per lb. of Seed	Period of Germination Approx. No. of Days	Age from Sowing at Time of Planting Months
		Days	Months
Acacia melanoxylon (Blackwood)	5,000–10,000	10–31	5–6
Brachylæna Hutchinsii (Muhugu)	1,000	9–20	8–10
Casuarina sp. ..	20,000	15–26	6
Cordia Holstii ..	500	14–27	5–7
Cupressus sp. ..	10,000	16–31	6–10
Dombeya Mastersii (Mukeo) ..	20,000	20–25	3–6
Eucalyptus globulus	10,000–20,000	8–18	4–5
Euc. citriodora / *Euc. maculata*	5,000–10,000	10–27	6
Eucalyptus, other sp.	10,000–20,000	8–27	6
Grevillea robusta ..	10,000	15–30	5–9
Juniperus procera (Cedar) ..	800–1,000	25–60	10–15
Olea chrysophylla	500	(Irregular) 4–12	8–13
Pinus sp. ..	2,000–10,000	18–22	10–12
Podocarpus ..	Variable, say 150	20–60	10–14
Premna maxima ..	500	23–27	6–8
Pygeum africanum	500–1,000	28–60	5–12
Vitex Keniensis (Muhuru) ..	Variable, say 100	25–50	5–9

Dangers to which the Plants are Liable.

"Damping off."—This is due to fungi and it normally indicates bad nursery practice or situation. The fungi are probably always in the soil, but they only become parasitic under excessively humid conditions. These arise when the plants are crowded, the air is stagnant, and the soil too moist. Dilute copper sulphate is normally used to check the spread of the disease, but dilute sodium or potassium permanganate has been used with excellent effects. This is applied from a watering-can. A small pinch of permanganate in each watering-can during the ordinary course of watering, sufficient to make the water claret-coloured, is enough, but stronger almost black solutions are effective, and do no harm to the plants. At the same time the overhead shade must be greatly reduced, as much air given to the seed beds as possible, and the seedlings severely thinned out.

Chafers.—The grubs of these beetles may be expected to appear in any nursery. They cause severe damage to young plants by gnawing and cutting through the roots. The seedlings should be transplanted to fresh beds as soon as possible, and the bed taken up and re-made with fresh soil. The grubs may often be picked out by hand from a bed if the infestation is not too bad.

Cutworms.—These are dirty-grey caterpillars, which bite through the roots of plants just below the level of the soil. They may be trapped by using the following mixture:—

Bran: 50 lb.
Paris Green: ½ lb.
Sugar (or salt): ½ lb.
Water: 2 gallons.

The sugar is dissolved in the water, which is used to moisten the bran, which should then be damp but not wet. The

Paris Green is worked in, stirring well. Paris Green is very poisonous, and a handkerchief should be tied over the mouth and nose when making up the mixture. It is better not to touch the mixture with the hands. 10 to 50 lb. of bait are sufficient for one acre. In a small nursery the grubs can be dug out by hand.

Sun-scorch.—This should not occur if the overhead shading is properly regulated.

Frost.—Damage from frost may occur in badly sited nurseries and also in those at high altitudes. Watering should be done in the early morning to prevent the rapid thawing of the plants.

Tree Planting.

The most important point to remember in planting trees is that, whether they are destined to produce fruit or fuel, their growth requirements are essentially similar. To get the best growth they should be given the best possible start and subsequent attention, due respect being given to the economics of the crop. Economically, it is naturally advisable to spend more on the planting and manuring of a coffee tree than on a Eucalypt destined to provide fuel. The fact remains, however, that a Eucalypt planted on properly cultivated and grass-free land will respond to such attention with maximum rapidity of growth, whereas one planted in a small hole in grassland will languish and probably die. The thick, matted roots of the grass and other weeds prevent the lateral expansion of the tree roots, rob them of food, and take first toll of water supplies in dry months, while hard, uncultivated land impedes rapid root penetration. To obtain satisfactory growth thorough cultivation of the soil is essential. It is hardly ever worth while planting in uncultivated grassland, however attractive the low initial cost may seem.

A.—Preparation of the Land.

Efficient cultivation may be obtained in the following ways:—

1. *Ploughing.*—There is no need to describe the methods of breaking and ploughing land for cultivation, except to say that it should result in complete destruction of grass growth, and that the deeper the ploughing the better.

The reason for this is that the sooner the plant can get its roots down to the deeper soil levels, where moisture is longer retained, the more chance it has of survival, and thorough breaking of the soil allows the tree roots to extend in the shortest possible time. It is almost impossible to exterminate all grass roots in a single season's ploughing, and grass seeds are continually being brought into a ploughed area. It is therefore almost invariably necessary to continue cultivation either by hand or machinery for some seasons after the tree crop has been planted. To cover the costs of this operation it is possible to grow catch crops of peas, etc., between the rows of trees.

In swamps, drainage must be combined with ploughing, and the perimeter type, which runs round the swamp and prevents excessive water from entering it, is of great value.

2. *Controlled Native Cultivation.*—This is the method widely employed by the Forest Department in reafforesting areas of forest that have been felled over for fuel or timber, or areas of bush that bear nothing of value on them. It has much to commend it, in that to plough old forest land postulates stumping, in itself very expensive, and that cultivation by paid labour also costs a lot. By the use of controlled squatter cultivation the land is prepared at no cost to the farmer, and

the squatter reaps the benefit of the crops he takes off prior to the planting of the trees and for a season or two afterwards. Stumping is not necessary. Since the squatter continues to grow crops amongst the trees till they become too big, weeding for the first year or eighteen months costs nothing.

The system may briefly be described as follows:—

The squatter is allocated a certain area of land, which should not exceed one acre for every wife he possesses. The reason for this is that, though a squatter will clear more than that in the first place, he cannot keep a greater area properly clean, and the results of suppression by weed growth in the early stages have a marked effect on the subsequent growth of the trees. Eighteen months are allowed before trees are planted in the natives' cultivation. This not only allows him time to obtain crops to repay his labour, but also ensures thorough cultivation of the soil. The native is allowed to take off further crops after the planting of the trees until eventually the growth of the latter prevents the cultivation of further food crops. He can then be given another area. It is advisable to encourage the native to fence the cultivation with the bush standing on the land before it is cleared and burnt. It is advisable to inspect the work periodically to see that—

(*a*) the native is not extending the area of his plot;

(*b*) he is not pruning off the lower branches of the planted trees to allow his crops more light and air; uncontrolled pruning is to be avoided;

(*c*) the cultivation is efficient and particularly that couch grass is thoroughly eradicated and kept out.

It is also advisable to forbid the introduction of any but annual and biennial crops, and castor oil trees particularly should be destroyed before cultivation ceases. If there are any old trees on the areas they should be felled, as not only do they impede the progress of marking out, but they also suppress the planted trees as they grow up.

Squatters are generally put into an area of bush or valueless forest which it is desired to plant up, but it is also possible to get them to cultivate in grassland. They will dig up Kikuyu grass turf, but it is worth the farmer's while to do a preliminary ploughing and harrowing, since this greatly eases subsequent hand cultivation.

3. *Shade and Specimen Trees.*—In the case of these complete cultivation of all the land is unnecessary. It is essential, however, that the holes in which the trees are to be planted should be at least 4 ft. wide and 2 ft. deep, and should the land be poor it is advisable to introduce into the holes better soil from elsewhere. In plantation crops manuring is not possible. but in this category it can do nothing but good, provided it is well mixed with the soil and not placed in a raw state round the roots. It is, of course, necessary to keep the grass from encroaching after the tree has been planted.

Isolated groups or single specimens of trees are very liable to be damaged by cattle or by game. They should therefore be protected where necessary.

B.—Planting.

1. *Marking Out.*—Before the work starts the required number of stakes should be prepared. They are best split from old bits of cedar, and should be about 2 ft. long and pointed at one end. The lining out is usually done with a woven wire rope, 200 or 300 ft. long. It is convenient to have about eight men to every hundred feet of rope, which is

marked off at the desired planting distance by bits of rag. It is advisable to see that each end of the rope is tied about a foot from the pointed end of a strong stick about 6 ft. long. This enables the men at the end of the line to dig the point of the stick into the ground and obtain sufficient leverage to pull the rope straight as the work proceeds. Plantations should be approximately rectangular in shape, as this saves trouble if the area is fenced or fire-protected later on. This is not, of course, essential.

If the area is to be planted out at 9 ft. x 9 ft., one boundary is marked off in a straight line, and stakes are placed at 9 ft. intervals along this line.

The next step is to set out the rope at right angles to one end of the line originally staked out. The two end men draw the rope taut, and the others, each of whom carries a bundle of stakes, put stakes in opposite the rags, and behind the rope. The man who is at the corner made by the original line and this second line now places his stick to which the rope is attached up against the next peg in the original line. The man at the other end of the rope will have been provided with a light measuring stick 9 ft. long. This he places in such a way that one end of it is touching the stake put in to mark where his end of rope reached, and the other end is straight of him. He then lifts the stick with the rope attached and places it in the ground again at the far end of his measuring stick, and levers the rope tight. The other men assist by lifting the rope over obstacles, and as soon as it is straightened out in its new position they again place stakes opposite the rags, and so on.

To save expense, lining out in native cultivation should be done before the maize grows up, but the work will have been wasted unless the pegs are firmly set in the ground. All planting pegs should be set firmly into the ground, so that they cannot be easily knocked out by cultivators, and for this purpose it is advisable to have a few men following the lining-out gang with mallets to drive in loose pegs.

Spacing	Number of Plants Per Acre
5×5	1,742
6×6	1,210
7×7	889
8×8	680
9×9	537
10×10	435

2. *Pitting.*—Before the rains are due a pit should be dug at each stake. The larger these pits are the better, but in practice, except for ornamentals and special trees, it is only possible for the pitting to be done with a hoe. The soil should, however, be disturbed to a depth of about one foot, and the subsoil removed, leaving a hole which can collect and bring to the lower soil levels any rain that falls. Humus is almost waterproof, and pitting has the good effect of removing any such layer that may exist, allowing all available moisture to penetrate below.

3. *Planting.*—It has been stated in describing nursery work that plants may be raised in boxes or in beds.

While it is cheaper, as far as nursery costs are concerned to raise the plants in beds, it is advisable in making plantations to use plants from boxes. This is because of the amount of root disturbance which the plants suffer while being transferred from the bed to the planting site.

A box of plants can be taken to the planting area, and the plant can be dug out of it on the spot with a ball of earth

adhering to its roots, and the minimum of root disturbance occurs. A better way still is to raise the plant in a banana-leaf pot, which can be planted direct, but in large scale operations the cost of this type of planting is prohibitive.

When plants raised in nursery beds are used they have to be lifted from the beds in the nursery. This requires very careful supervision to ensure that they are dug up carefully and not pulled up with a consequent breaking of roots. It is impossible to keep a ball of earth on the roots, and the plants are liable to harmful exposure and drying out during transport to the planting area and during the period that must elapse after arrival at the area before each tree can be planted. However carefully they may be lifted and covered with moss and damp soil for transport, the risk of damage is greater than if they were taken from boxes. Plants from boxes are therefore recommended.

If plants from beds are used, the earth in the bed should be thoroughly loosened with a fork to such a degree that the plant can be lifted with the application of the minimum of force. Labourers are far too apt to dig in a *panga*, loosen the soil slightly and pull out the plants by force, a fatal operation because all the fibrous roots, the most important for successful planting, are then torn, and the plant's chances of survival much reduced.

The usual planting tool is the *panga*. In the pit already dug at each stake in the cultivated land a round hole, 6 to 9 in. deep is dug, the plant is held in it with its long roots set vertically downwards; if the hole does not prove to be deep enough, it should be made so, rather than that the roots should be curled up at the bottom of it. The collar of the plant, i.e. the point where the stem naturally disappears into the earth in the nursery, should be set in a similar relative position, and the whole plant held against the side of the hole. The planter then collects with his free hand surface soil, not subsoil, from round about, and pours it into the hole until it is half filled. This soil should be firmed with the hand against the side of the hole where the plant is held. Further soil should then be added and firmed in with a downwards and sideways motion until the hole is filled. The object of placing the plant against the side of the hole is that it is then easier to hold the plant at the correct height with the main roots set directly downwards while the soil is packed round them. It is not the ideal way, but safest when much planting is to be done. The preliminary sideways firming is to ensure as far as possible that the fine lateral roots shall not be torn by a premature downward pressure before the roots have been set by the sideways pressure. The packing must be firmly done, so that no air pockets are left round any part of the roots.

The operation has been explained in detail, seeing that too much stress cannot be laid upon its importance. The essential point is to get the end of the root straight down to the greatest possible depth, and not twisted upwards, with, possibly, the end of the root in the air. The deeper the root reaches the longer is the plant going to endure a dry spell; the plant with a root depth of 3 in. naturally dying sooner than one with 6 in. On no account, however, must the young tree be planted deeper than the collar. If roots are very long the end may be nipped off. This is better than doubling it up, and possibly better than making holes to inordinate depths.

It is of great importance that the soil should be well firmed round the roots to

exclude air and to allow them to take hold at the earliest possible moment. It should not be possible to pull up the plant after planting except with the application of some force.

If the trees have been planted amongst food crops they will be automatically shaded until the food crops are reaped, by which time the trees should be established. If, however, they are on open ground they may have a harder time. Where the area is not great and the expense can be afforded, they can be shaded for a time with grass. Such shade should not be kept on too long, since by shading the plant from sunlight it tends to weaken it, and if wet weather returns it may induce mould. Big plants are better than small plants, as the longer and more fibrous the root system is, the greater the likelihood of their survival. Small plants with 2 to 3 in. of root have little hope in dry weather.

It is also a good thing to mulch round newly planted trees by spreading rubbish on the ground round the stem. Such mulching helps to prevent the soil drying out.

Planting seasons vary, and the time of planting must be left to individual judgment and experience. It should, however, be remembered that if plants can be planted successfully in the April-May rains almost a year's growth has been gained. These early plantings establish themselves during the May rain, hang on through the drier month of June, and then with the July-August rains they begin to grow, while the July-August planting is merely establishing itself before the dry weather, and does not grow much till the following year, unless it happens to have good rains in November. These remarks refer to the western half of the Colony, not to the Nairobi-Nyeri area, where it is a case of planting in April and May, or probably not at all.

All planting should be finished at least a fortnight before the rains are expected to end.

Every effort should be made to have a plantation as complete as possible at the end of the first planting season. If there are blanks in the following year, they should be "beaten up", but it should be remembered that replacements will only grow to a good size if the blank is large. One replacement amongst other established trees will seldom come to maturity but will be suppressed by its neighbours.

4. *Tending.*—In the first few years of the life of the plantation tending is mainly confined to protecting the young plants from weeds. Grass, especially of the couch variety, chokes the roots of the trees. Creepers and overhanging bushes smother their crowns and branches, and should be rigorously kept down. Straight-growing weeds, however, which do not overtop the tree, but merely grow at an equal rate with it, do little harm, and tend to shelter the plant from the desiccating effects of sun and wind. They further protect the soil, but must not be allowed to become too dense. To assist in elimination of weeds, the space between the tree rows may be cultivated, and catch crops of maize, peas, etc., taken off.

With the closing of the canopy the danger from weeds disappears, as they are suppressed under the shade of the plantation, and the problem of thinning begins to appear.

The object of any plantation is obviously to produce the maximum quantity of forest produce of the desired quality per acre in the shortest possible time in the cheapest possible way. Forest produce may be described roughly as fuel, poles or millable timber. If the object of

management be firewood on a short rotation (that is, if the trees are to be cut as soon as large enough for fuel) it is possible to plant at a 9 ft. x 9 ft. spacing and cut at 8 to 10 years old. If, however, saw timber is the object of the plantation, it is not possible to allow the trees to remain till maturity at the spacing at which they were originally planted, and during the life of the crop thinnings must be made. The object of the thinnings is so to regulate the density of the trees that the greatest number may be grown on the area consonant with the necessity that every tree should have sufficient room to put on the maximum growth while side branches are kept suppressed and small. In the younger stages, 1,000 or more trees may be able to grow on an acre. As they become older and bigger their demands on soil moisture increase and their crowns automatically become crowded and consequently small. Food supplies therefore, both from root and leaf, are restricted and growth tends to fall off or cease.

It is the object, therefore, of thinnings so to reduce the number of stems in a plantation as the years pass that the trees left may be relieved of competition, both in root and crown, from those that are thinned out, and consequently produce maximum growth. Thus a plantation which began life with 800 to 900 trees may end with a final crop of less than 100. This being the case, it might appear sufficient to plant only the number required for the final crop. Trees, however, grown for timber production need clean straight boles, and this is best obtained by crowding them together in early years, and gradually reducing such crowding by proper thinning. Furthermore, thinnings are of value, and the early revenue which they bring in tends to repay to the owner at the earliest possible moment his costs of planting. This is especially necessary in a long-lived crop such as timber trees. The complete covering of the ground is also necessary at the earliest possible moment, not only to keep down weed growth, but also to preserve and increase the humus layer and thereby the quality of the soil.

Trees in plantations which are left too long in an overcrowded condition rapidly develop poor crowns, and once that has occurred, even with drastic thinning, they take a long time to recover their full vigour, if indeed they ever do. Suppression due to congestion of crown and root ssytems in the early stages of life has a markedly detrimental effect on increment, and correct thinnings are of the utmost importance in the treatment of timber plantations. The aim should be to keep the trees close enough to kill off side branches, while allowing the tree to retain at least one-third of its total height as a green, strongly growing crown.

Protection.

Fire.—Plantations must, of course, be protected against fire, and the usual method is the clearing of fire lines, 15 ft. to 20 ft. wide, round them at the beginning of the dry weather. Further protection may be afforded by sweeping up the litter beneath the trees for some yards along and within the plantation edge. Where grass adjoins the plantation, it should be burnt off or grazed short, or by other means kept non-inflammable.

In dangerous areas fire patrols and in large plantation areas a system of internal rides and fire lines are essential.

Game and Vermin.—Certain species, such as Mukeo, Mueri, Olive and Blackwood, are especially liable to be browsed down by game. Fencing is practically the only remedy for this over small areas. Over large areas the damage is less con-

centrated, and the majority of the trees will usually get away. Some protection can be given by placing tree or shrub branches round individual trees.

Another annoying form of damage is that caused by bush buck rubbing their horns against saplings. The bark is removed and the tree frequently dies. Isolated trees can easily be protected with posts, but small groups might be destroyed altogether in three or four years if they are not fenced. In large areas again the damage is unconcentrated and not serious.

It is almost impossible to plant up certain areas of grassland where mole-rats are plentiful. These animals are particularly fond of *Acacia melanoxylon* and certain Eucalypts. Cypresses are normally comparatively immune, but may be attacked.

Where mole-hills are plentiful on the proposed planting area, a trapping campaign must be undertaken, and the area must be kept free of these pests until the trees are at least 5 in. in diameter at the base of the stem.

Cypress trees are sometimes attacked by field rats and mice. The damage consists in the ring-barking of trees between 2 in. and 6 in. in diameter, normally just above ground level. The remedy is to clear away all the undergrowth for a space of at least two feet from the base of the tree, and to prune the lower branches for a height of several feet. Hawks, owls, and the small carnivora can then see the rats working in the open.

Stock.—A plantation should not be turned into a grazing ground, nor should a grove become a cattle *boma,* if wood and not shade is the object of management.

Woods improve and maintain the quality of the soil by the deposition of humus from their own leaf fall. To preserve this humus is essential, and a woody ground flora is the best way to do so. Stock not only destroy the ground flora and humus and encourage the growth of grass, but by their trampling they harden and bare the soil, to its detriment. Plantations and grazing do not combine to the benefit of the plantation. Even trees planted in the open, with the idea of giving shade to cattle, should be protected by small fences two or three feet from the actual stem.

Such, in brief, is a description of the methods whereby plantations may be made and brought to maturity.

It may be as well at this point to remark that for some purposes, where tree growth is wanted, the best results are not always obtained by establishing plantations, but by encouraging those species of tree and bush which are already growing on the land. This particularly applies to the protection of streams, springs, and steep hillsides. Further reference is made to this at the end of these notes.

The following notes deal more particularly with the methods necessary in establishing plantations with varied objects of management. The systems described are based on conclusions drawn from experience gained in the management of plantations made and maintained by the Forest Department in Kenya.

TIMBER PLANTATIONS.

These may be divided into five classes:—

1. Indigenous Conifers.
2. Indigenous Hardwoods.
3. Exotic Conifers.
4. Exotic Hardwoods.
5. Fuel Plantations.

The following notes indicate the general lines on which it is believed that plantations of various kinds should be initiated and tended in Kenya.

1.—*Indigenous Conifers.*

These are the East African Pencil Cedar (*Juniperus procera*), and the two *Podocarpus* species, *P. gracilior* and *P. milanjianus*, both commonly known as Podo.

The Forest Department are growing but little of either of the Podo species, because it is believed that the Cypress plantations which it is making, and which are described under No. 3, Exotic Softwoods, will produce timber of equal or greater value in a considerably shorter time.

Cedar, however, is a valuable wood with special qualities, not the least being its durability against rot, borers and white ants.

Cedar should, generally speaking, be planted at 7,000 ft. and over. It is considered best to plant it in alternate line mixture with another tree (a broad leaf species, which is known as a nurse tree). Its spacing should be 12 ft. x 6 ft., with a similar spacing for the nurse tree, making a plantation of trees mixed at 6 ft. x 6 ft. in alternate rows.

The best nurse tree is Brown Olive (*Olea chrysophylla*). As it is desirable to have some mixture in the final crop, at least every tenth tree in the cedar lines should be of another species, such as Podo or Mueri, which produce useful timber and grow at much the same rate as Cedar.

Cedar in plantations grows at the rate of about two feet a year. Olive in most districts grows slightly faster. The following treatment should be given to the plantation, starting in the third year from planting:—

Age in Years	Treatment of Plantation
3–4	Prune branches of cedar up to 2 feet from ground level and pull off creepers.
6–7	Prune cedar up to 5 feet from ground level.
8–9	Prune cedar up to 10 feet from ground level. Cut out the worst stems on each olive tree, leaving one or two good stems only per tree.
11–12	Select about 300 good cedar trees per acre (i.e. about half the number planted) and prune these up to 15 feet from ground level. Leave the remainder unpruned. At the same time prune the podo and mueri in the cedar rows to the same height. Cut down any big olive that are badly swamping the selected cedar trees in the cedar rows.
14–15	Prune the trees selected in the 12th year up to 20 feet from ground level and cut back any olive that are swamping these trees.

Treatment in the first two years should aim at keeping the ground free from grass, weeds, creepers, etc. This is done by the squatters who are cultivating in the plantation for food crops. After the 15th year the correct treatment has still to be investigated. It will aim at further successive prunings of the cedar and some thinning in all species.

2.—*Indigenous Hardwoods.*

There is always a limited market for hardwoods, and the Forest Department, by aiming at producing 25 per cent of hardwoods in the final crop of its coniferous plantations believes that this will to a great extent meet the demand.

There are, however, various special indigenous timbers which are well worth growing in warm country, say between 5,000 and 6,500 ft. altitude, with a rainfall of not less than 45 inches. Such are Muringa (*Cordia Holstii*), Muhuru (*Vitex keniensis*), Muchichio (*Premna maxima*),

and Satinwood (*Fagara* nr. *macrophylla*). The growing of these is still very much in the experimental stage, and the following notes are as much as can be said as yet: —

Cordia Holstii (*Muringa*).—A beautiful red lightweight cabinet and joinery wood. For the first few years of its life it often grown as a many-stemmed bush. After that, one stem generally takes the lead and gets away from the others. It is then probably advisable to cut away the remaining stems, though this is not yet proved. Even this leading stem is generally very crooked, and continues to grow with many angles. It should therefore probably be grown with a straight and faster growing tree to discourage this tendency, though this only helps to a limited extent. A spacing of 7 ft. x 14 ft. in mixture with *Grevillea robusta* is probably sound, but care must be taken to see that the Grevillea does not swamp the Cordia. When this begins to occur the *Grevillea* must be thinned to free the *Cordia*. It does not seem that pruning helps to any great extent, but experiments in this line are continuing.

Vitex keniensis (*Muhuru*).—A light, straight-grained wood of fair strength and good appearance; an erect-growing tree of symmetrical habit, but requires care in growing to produce long lengths of straight bole. It is too early to give any useful information apart from the fact that it persistently tends to develop several leading shoots, which must be checked by pruning or growing in dense stands. It is probably best grown in intimate mixture at 7 ft. x 7 ft., with a tree of similar growth, i.e. about 3 ft. a year. Macaranga (Mukuhukuhe) may prove a suitable mixture in areas in which it grows, and is being planted experimentally by the Department. It grows faster than *Vitex*, and will need heavy thinning.

Muchichio and Satinwood.—These are both excellent timbers and fast growing, at any rate in youth. Their requirements are probably much the same as the preceding species, but little is known of their behaviour in plantations except in very early stages.

Muhugu.—Muhugu may be planted in districts where it is indigenous, i.e. Nairobi and Nyeri, at an altitude of 6,000 ft. and a rainfall of 35 inches. The best mixture is Muhugu in alternate lines with Muho (*Markhamia*) at a spacing of 6 ft. x 6 ft. Growth is slow—about two feet a year.

3.—*Exotic Conifers.*

Probably the most profitable timber crop to grow is the one which comes into this category. Softwoods, i.e. general utility deal timbers, are always in demand.

Above 7,000 ft., and with a rainfall of 40 inches and over, experience appears to indicate that the best tree to grow is Cypress. There are several species of this, but the two principal types are *Cupressus macrocarpa* and *Cupressus lusitanica*, which, so far as is known, produce equally good timber. Among most Cypresses, but especially *C. lusitanica*, there are many different forms, some strains producing a large proportion of crooked-growing trees. Seed therefore should either be collected from trees of good form well removed from trees of bad form, to avoid the effects of cross-fertilization, or be bought from a reliable source.

The Department's experience of Cypress-growing has not been sufficiently lengthy to enable absolutely definite conclusions to be reached, but from results so far obtained it is considered that methods should approximate to the following general scheme.

Species and Mixtures.—*C. macrocarpa*

should not be planted if the rainfall is less than about 42 inches. *C. lusitanica* will stand drier and warmer conditions, say down to a rainfall of 36 inches. If it is desired to plant Cypress in still drier conditions, local experience seems to show that *C. torulosa* (Himalayan Cypress) will grow successfully down to an altitude of 6,000 ft. with a rainfall of not much more than 30 inches. Below 6,000 ft. Cypress should not be planted for timber.

Cypress can be planted pure quite successfully, but the Forest Department prefers mixed plantations. They require more skill and attention in management, but they keep the soil in better condition, produce a variety of timber, and probably reduce disease risks. At present the Department is planting Cypress and *Grevillea robusta,* and occasionally Mukeo, the intention being to have 25 per cent of hardwood in the final crop if possible. Other species in mixture are being tried on an experimental scale only.

Spacing.—Cypress is planted 8 ft. x 16 ft. in alternate rows with *Grevillea,* also 8 ft. x 16 ft., making the spacing of the plantation on the whole 8 ft. x 8 ft., or 680 trees per acre.

Management.—Thinning and pruning in the plantation should be carried out in accordance with the following schedule: —

First Year.—Trees still being weeded or under cultivation by squatters. Prevent damage to young trees by climbing crops, such as peas and beans. Re-plant blanks in the plantation.

Second Year.—When squatters have left plantation, the plantation must be gone through at least twice a year (up to four times in a year of abnormally heavy rainfall) to remove creepers and climbers and the more vigorous weeds from the trees.

Third Year.—Height of Cypress 8-10 ft. Prune the branches of the Cypress up to 3 ft. from ground level, at the same time removing creepers.

Sixth Year.—Height of Cypress 20-30 ft. Cut out half the *Grevillea,* as far as possible by the removal of alternate trees in the row. Cut out all dead and misshapen trees in the Cypress, and also trees which are heavily overtopped by the normal trees and therefore likely to get suppressed under their shade. This thinning should leave about 270 to 280 Cypress trees per acre. (The plantation at 8 ft. x 16 ft. started with 340 Cypresses per acre if it was complete.) Prune the branches of the Cypress to 8 ft. from ground level.

Ninth Year.—Height of Cypress 35-40 ft. Cut out all dead, misshapen and overtopped Cypress trees, as in the sixth year thinning. There should be 240 to 250 Cypress trees left per acre after this thinning has been made. Prune the branches of the Cypress up to 18 ft.

Some *Grevillea* trees will need to be cut out to allow the remaining Cypress trees uninterrupted room to develop. There should be about 120 to 130 *Grevillea* to the acre after this thinning.

Twelfth Year.—Height of Cypress 50-60 ft. A further thinning should be made in the twelfth year, to aim at leaving about 200 Cypress trees and 80 to 90 *Grevillea* trees per acre. The poorest trees should be cut, but bearing in mind that the trees to be left standing should be as evenly spaced as possible. Prune the branches of the *Grevillea* up to 18 ft. from ground level, i.e. the same height to which the Cypress were pruned in the ninth year.

Fifteenth Year.—Height of Cypress 65-75 ft. Cut out any trees which have died or become misshapen or broken since the last thinning was made, and

also remove sufficient Cypress trees so that only good trees with full crowns and well-shaped boles remain evenly distributed over the plantation and with room for proper crown development during the next ten years. The stand in the plantation after this thinning has been made should be approximately 170 Cypress and 50 to 60 *Grevillea* trees per acre. Prune the branches of Cypress and broad-leaved trees from 18 ft. up to 36 ft. from ground level. The plantation will be left in this state to grow on to saw-timber size, which will probably be reached at about 40 years. Further thinning will probably be necessary in the interval, but the Department has as yet no experience of the treatment of plantations in this later phase. No statistics are available for the yield of timber at maturity, but it appears probable that Cypress should yield 6,000 to 8,000 cubic feet per acre at 40 years old.

4.—*Exotic Hardwoods.*

Australian Blackwood (*Acacia melanoxylon*) is a fast-growing tree with an extremely decorative wood, often attractively figured. The heartwood varies in colour from reddish brown to almost black, streaked with a golden or reddish tinge. It is a strong timber, and is useful therefore for constructional work, as well as ornamental purposes, for which its attractive appearance makes it particularly suitable, e.g. panelling, furniture, and cabinet work generally. It is somewhat exacting as regards moisture, and should not be planted under 7,000 ft. or where rainfall is less than 40 inches per annum. A cold, damp climate is what it prefers. It should be planted at a spacing of 8 ft. x 8 ft., and thinned by degrees to not more than 250 trees per acre at 10 years of age. The thinnings make good straight poles or first-rate charcoal. Buck are fond of browsing the leaves of the young trees, and fencing or making small guards round each tree may be necessary. The trees may be pruned up to 30 ft. at 10 years old.

Victorian Oak (*Eucalyptus regnans*) is another tree requiring a similar climate to Australian Blackwood. Its rate of growth in a suitable climate is phenomenal, sometimes exceeding 12 ft. a year in early life. Its timber looks very like English oak, but without the figure characteristic of the English wood. It should be planted at a spacing of 10 ft. x 10 ft., and thinned by degrees to not more than 150 trees per acre at 10 to 12 years old.

Australian Silky Oak (*Grevillea robusta*) has already been mentioned as a suitable tree to plant in mixture with Cypress. Its moisture requirements are not so exacting as Australian Blackwood and Victorian Oak, and it may be expected to produce timber in areas of rainfall down to 35 inches per annum. The timber itself is pale brown, and has a handsome figure similar to English oak. To obtain the best figure it must be cut on the quarter, i.e. so that the face of the board is at right angles to the concentric growth rings. The wood is considerably lighter than Blackwood and slightly lighter than Victorian Oak, but is very much easier to work than either of the other two. It makes a decorative cabinet or furniture wood; it can also be used for bent work, such as motor bodies.

If planted by itself, 8 ft. x 8 ft. is a suitable spacing; thin to 300 trees per acre by the tenth year, and prune to 25 to 30 ft.

Eucalyptus saligna produces a valuable timber, and is another hardwood worth planting in districts of good rainfall (over 40 inches per annum), and not too cold, e.g. not above 8,000 ft. It should be

planted 10 ft. x 10 ft. and thinned by degrees to not more more than 150 trees per acre at 10 to 12 years old.

Eucalyptus sideroxylon and *Eucalyptus maculata* are probably the two species most worth planting in drier districts with annual rainfall 30 to 35 inches. *Sideroxylon* produces a durable timber, and is one of the strongest of Australian timbers. *Maculata* is not as strong as *sideroxylon*, but has considerable resilience and bending properties; it is a useful wood for tool handles and pick handles, and it is popular in South Africa for many purposes. *Sideroxylon* is mainly used in constructional work, especially in the ground, on account of its great durability. These two species should be planted 8 ft. x 8 ft., and thinned by degrees to 230 to 250 trees per acre at 10 years old.

Further thinnings will be needed in all the above species between the tenth and twentieth years.

The following number of trees per acre should be aimed at by the twentieth year: Blackwood and *Grevillea*, 130-150; *Eucalyptus regnans* and *E. saligna*, 50-60; *Eucalyptus sideroxylon* and *E. maculata*, 70-80.

5.—*Fuel Plantations.*

Where firewood is wanted one obviously cannot afford to plant slow-growing species. The most suitable trees are Eucalypts or Wattles, both of which produce good fuel. Both have advantages. Wattle should only be planted where soil and rainfall are good. It is perhaps slightly the better household fuel, and can be sown direct instead of having to use transplants. Eucalyptus is an excellent fuel when well dried out; it produces more per acre than Wattle, and makes a more permanent plantation, since it will re-grow by shoots from the stumps when cut. Also different species of Eucalyptus are suited to different kinds of soil and climate.

Eucalyptus.

Species.—*Eucalyptus globulus* (Blue Gum) and *Eucalyptus saligna* (Blue Gum of New South Wales) are the two best species for fuel plantations in districts with a mean annual rainfall of 35 inches or more on sites with fair depth of soil. For drier areas these two species are unsuitable, and more drought-resisting ones should be planted. Two of the faster growing hardy gums are *Eucalyptus maculata* (Spotted Gum) and *Eucalyptus citriodora* (Lemon-scented Gum). If seed is obtainable, *Eucalyptus maideni* is probably better in moderately dry sites, being apparently fairly safe, and certainly much faster. In very dry districts it will be safer to plant *Eucalyptus sideroxylon* or *E. siderophloia.*

Spacing.—*Globulus* should be planted 9 ft. x 9 ft.; *saligna*, 10 ft. x 10 ft.; *maideni*, 9 ft. x 9 ft.; *maculata* and *citriodora*, 8 ft. x 8 ft.

At the 10 ft. x 10 ft. spacing special care must be taken to ensure a complete stand. Only good-sized plants should be used in "beating up", which should be done at the earliest opportunity.

Rotation and Yields.—A rotation of ten years is considered suitable for *globulus*. *Saligna* hardly reaches satisfactory dimensions in this time, and should be left to grow for 12 years before felling. *Maculata* and *Citriodora* will require at least 12 years in which to grow to a sufficient size for fuel billets.

Globulus in 10 years and *Saligna* in 12 years should reach 7 to 8 inches mean diameter and 80 to 100 ft. height. The yield of fuel should be 3,000 to 4,000 stacked cubic feet per acre. *Maculata* will

not give more than 2,500 stacked cubic feet per acre at 12 years old.

In the second rotation, i.e. coppice shoots from the stumps of felled trees, the yield of fuel at 10 years old will be considerably greater than that of the first crop. The only figure at present available is for *globulus* (at Elburgon), which yielded 10,800 stacked cubic feet per acre at 10 to 11 years old. An average of 8,000 stacked cubic feet per acre should be obtainable from second rotation crops of *globulus*. It is doubtful if *saligna* will give as great a yield from second rotation crops as *globulus*. Probably an average of 6,000 stacked cubic feet per acre will be obtained.

Treatment of Coppice.—Some months after the first crop has been felled coppice shoots will appear from the stumps. The number of shoots that each stump produces varies with different species, but in every case the number must be reduced by thinnings, as the best yields will not be obtained by leaving all the shoots to grow to maturity.

In the third or fourth year after felling the coppice shoots should be thinned to two stems per stump. Coppice of *saligna, globulus,* and *maideni* will at this age be 30 to 40 ft. in height, and the stems removed will be useful as poles for temporary use; they are not durable.

In plantations exposed to strong winds it is advisable to make a preliminary thinning of the coppice shoots, leaving three stems per stump, and to go through the plantation a year later, cutting out one of the three stems where all three are still growing. On many stumps it will be found that one stem has been broken by wind, and in this case no further thinning is required. At the same time any new coppice shoots that have appeared from the stump since the preliminary thinning should be cut out.

Wattle.

Wattle should be sown in well cultivated land at a spacing of 11 ft. x 5½ ft., i.e. rows 11 ft. apart and trees 5½ ft. apart in the rows. A few seeds are sprinkled at each planting place when rain is expected. Before sowing, the seed should be treated by placing in a pot of boiling water which is then immediately removed from the fire and allowed to stand for twelve hours. Seed treated in this way will keep for a long time, provided it is properly dried on a tarpaulin before storage.

When the seedlings have come up and are about six inches high, all except the best looking plant at each planting site should be pulled up; this should be done in wet or misty weather. Soil should be firmed again round the remaining plant if necessary. When the trees reach 6 to 10 ft. in height, they should be spaced to 11 ft. x 11 ft. by cutting down alternate trees in each row.

Wattle is ready for felling at 8 to 10 years old, when the bark should be sufficiently mature to fetch a good price for tanning, but on good soils in districts with 40 to 50 inches rainfall, it is worth while leaving the crop until 12 years old, since it will grow a great deal in the last two years before felling.

Trees should be felled systematically from one end of the plantation, as wood is required, so as to leave ground clear for regeneration of the new crop.

Dry wattle is an excellent firewood, but when green it is poor. It should therefore be stacked to dry out for some months. If there is danger of theft of fuel in billet-stacks, left near the plantation, the poles may be carried out to the edge of the plantation if cut to 10 ft. lengths and left to dry in this form. In any case, the wood should be removed from the plantation as soon as cut, so as not to

impede the germination of new seedlings. When the ground is cleared the area should be lined out in rows 11 ft. apart, with pegs 5½ ft. apart in each row. On sloping ground the rows should run across, not up and down the slope. Any brushwood left from the previous crop should be piled between the rows.

In normal circumstances germination of seedlings will appear all over the area within a month or two of felling the previous crop. All the seedlings that come up between the rows must be pulled up, and of those in the rows only one good seedling left at every 5½ ft. and the remainder pulled up, so as to leave the plantation clear of all wattle except the selected seedlings, which will be spaced 11 ft. x 5½ ft. Pulling up of weeds and unwanted wattle seedlings will have to be repeated several times in the first two years.

When the trees reach 6 to 10 ft. in height, space them to 11 ft. apart in each row by cutting out alternate trees.

If there is sufficient bark to be worth considering for sale, it should be stripped as soon as the trees are felled, carefully dried, bundled and stored under cover until it can be disposed of. Thin bark is of little value, nor is bark which has been allowed at any time to get mouldy.

Protection of Streams, Springs and Hillsides.

This problem has exercised the public mind to an increasing extent in the last few years. The effect of forest on rainfall is a highly debatable one, and is dealt with in Pamphlet No. 2 of the Forest Department (which has been reprinted in this Journal). It may be said here that, while it is probable that in certain circumstances forests and tree growth, by reason of the lower temperature which they induce, do tend to condense atmospheric moisture as well as add to it through transpiration from their leaves, there can be no doubt that they perform a function of first-class importance in preventing denudation of stream-banks and hillsides and in water conservancy and the regulation of stream flow. On farm lands and native reserve in hilly country it is emphatically of supreme importance that stream-banks and steep hillsides should be protected.

As a rule, the most satisfactory form of vegetative covering is provided by the local flora. Such plants are generally more moderate in their demands on soil moisture than exotic species, and they are by habit suited to the exigencies of the local climate. It is well worth while to study the trees and shrubs that grow in the neighbourhood of the area which it is desired to protect and to choose for river shade trees those that may already be found in places along the banks. To reafforest slopes and stream-banks, the cheapest method to adopt is that of strict protection of the area to be dealt with from fire, cultivation, habitation and grazing. The method may be slow, but it is astonishingly sure. Gradually shrubs will appear, and in course of time an invasion of tree species will also occur. Although uncontrolled grazing of such areas may produce feed for animals for a certain time, according to the nature and richness of the soil, it is certain that constant trampling and browsing will eventually destroy the soil covering, and deterioration then sets in which it may be impossible to repair, except at great expense.

The present notes are not the place in which to discuss soil erosion, but it is relevant to emphasize the very satisfactory results that can be obtained through efficient protection of an area from the attacks of fire and man and beast.

Mixed Farming in East Africa

III.—Starting a Dairy Herd in Kenya

By J. F. LIPSCOMB, *M'tarakwa, Kinangop, and* R. S. BALL, *M.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Kenya Colony.*

The necessity for the introduction of a mixed farming system in the arable areas, with a dairy herd as one of its essential units, has been discussed at length in previous articles in this Journal.

The chief problem, however, is that of the man with small capital, or with borrowed capital, who desires to make this change-over with the minimum of cost and yet secure a cash return as soon as possible. Some farmers, however, who have had the money available have spent it liberally on high-grade cattle, introduced, in many cases, from a clean area into a dirty one without taking sufficient steps to clean up the land, with the result that their losses have been very severe and their capital has been partly wasted. Great emphasis must therefore be laid on the necessity for pursuing a slow and careful policy in the initial stages, and making sure that the land is thoroughly clean from tick-borne diseases before valuable stock is purchased. This may necessitate some delay in the establishment of the herd, but it is a policy that will be amply repaid in the future.

In these dirty areas, therefore, the first necessity will be the building of a dip and the subsequent dipping of all working oxen and other immune native cattle that may be on the farm. These cattle should be grazed heavily on all the areas over which the dairy herd is likely to run, this land being fenced at least with a ring fence if the expense of paddocking is too great. The length of time needed for this operation will obviously vary greatly from district to district.

The problem that next arises is to decide what stock to purchase at the beginning, and here of course individual opinion will vary considerably. It is important to remember, however, that much of the low-grade dairy stock that are on offer in this country, when the dairy industry is expanding so rapidly, are culls from herds that are being improved, with the result that many are likely to be either poor milkers, difficult to handle or milk, or may have lost a quarter or suffer from udder troubles which only become apparent when the animal calves. The obvious course to pursue would therefore appear to be to buy half-bred or higher grade in-calf heifers as the nucleus of the herd, but it must be remembered that these are the cattle most in demand at the present time, and therefore likely to be very expensive. In many cases therefore the farmer will decide to start with selected native cows and a pure-bred bull of a suitable dairy breed, being content with a small income from these until such time as their half-bred offspring begin to calve. Such a policy is particularly suited to a dirty area, where there is still a doubt whether the land has been thoroughly cleaned up, since the native cattle will, in all probability, be immune with the exception of one or two types, and the policy of cleaning up can therefore proceed, using this stock for the purpose. The pure-bred bull can be kept under restricted conditions on a piece of land which has been thoroughly cleaned.

Another advantage of this policy lies in the fact that the farmer will be breeding cattle of one type from the start,

since it would be difficult to purchase a herd of low-grade cattle conforming to one type, and the segregations that are likely to occur in the progeny, even if sired by the same bull, will probably produce a certain number of very indifferent animals.

It is important, however, to emphasize the fact that if the policy is to commence with native female stock, using a pedigree bull, the income derived will be low until the half-bred progeny come into milk, which will not be until three years after the herd has been started. If native cows already in calf to a native bull were originally purchased, this period will be extended up to nearly four years. Secondly, it is becoming increasingly difficult to purchase large numbers of native heifers, and it is desirable that a considerable number should be available in order that selection can be made on a fairly extensive scale, so that only animals of a promising type are used as the foundation of the herd. It should be possible to dispose of culled native immune animals at a price that is commensurate with that originally paid for them. This is not, however, always possible in the case of culled grade animals, since they can usually only be sold for slaughter, for natives will not buy them owing to their susceptibility to tick-borne diseases.

The advantage of such a policy when possible will, however, at the end of this period become abundantly apparent, because the farmer will have a herd uniform to one definite type, his land should be largely freed from tick-borne diseases, and, in the case of a man who has not had much previous experience of stock, this will have been gained mainly at the expense of cattle that were cheap in their original cost and not so sensitive to indifferent management as higher grade animals would have been.

It might be possible in some cases to establish the nucleus of a herd by the purchase of old cows from a good herd. Such animals would be culled on account of falling milk yields, the desire of owners of such herds being to maintain a high herd average for the purpose of selling bulls. Such cows should if possible only be purchased if they are known to be in calf and free from udder troubles. In this manner the foundation of a good herd would be quickly laid, since the heifer progeny of this stock would be of high quality. Such a policy would be best suited to a farmer whose acreage of land is restricted and who therefore wishes to obtain the maximum yield per cow.

Equipment and Lay-out.

The design and construction of the milking and calf-rearing outfit are the most important problems in this connection. The advantages of portable milking outfits over permanent ones have been fully discussed in a previous article in this Journal (Vol. I, No. 5, March, 1936: "Mixed Farming in East Africa"), and the relative merits of both elaborated. On the small mixed farm the permanent unit will probably predominate, but even here much depends on the type of grazing, etc. Whatever building or buildings are constructed, however, they must be well protected from rain, since a cow standing in driving rain will often hold up her milk, quite apart from the milker's natural disinclination to do the work properly under such conditions. Calf-feeding arrangements should be such that each animal can be fed separately, so that they cannot suck each other. One of the most suitable systems for this is the portable calf pen, about 5 ft. by 4 ft. in area, surrounded on all sides by a pig netting to make it vermin-proof, and if necessary boarded up on two sides from the pre-

vailing wind. This pen has no bottom to it; it just rests on the grass, and is moved frequently, preferably daily, and in this way danger from diseases such as white scour, which are often troublesome in a permanent calf house unless provided with a very good floor and frequently disinfected, can be largely eliminated. Another system, well suited to a large farm, is the construction of purely temporary rough stick and grass pens in which the calves are kept separately for the first three months, and the pens are then destroyed; but if one or other of the above systems is not adopted, it becomes necessary to erect a permanent building. If this is done, it must be provided with a hard floor and sides which can readily be disinfected, and the expense of this is naturally considerable. Whatever system is adopted, however, it is very desirable to have the calf-pen close to the milking unit and separator room, so that the whole milk and skim milk that are being fed will be at a proper temperature. If these are fed cold, particularly to young calves, serious trouble and frequently death will result. In cases therefore where the milking and separating unit are portable, the type of movable calf-pen described above is likely to prove the most suitable.

When a permanent system of milking and housing of rearing stock is adopted, great care must be paid to flooring; the necessity for hard roads to the building must be emphasized, so that in-calf cattle are not likely to damage themselves by straining through the mud during the rains.

While it will probably be necessary to allow the progeny of all native cows to suckle on their dams, yet the calves which are the progeny of the first cross-bred heifers will, if possible, be hand reared, so as to obtain strict control over the amount that each animal receives, ensuring that it obtains the correct amount daily. There may be a temptation to starve the rearing calves of whole milk in order to get the maximum output of butterfat, but this is a policy that will never pay in the long run. After the grade herd has been established, the original native cows can be used for fostering calves. There is, in addition, usually a cow or two in the grade herd that, on account of udder trouble or difficulty of milking, is best used for fostering calves, and, particularly where there is any likelihood of infection through the hands of milkers milking such animals, they should be allowed to suckle their own and possibly a fostered calf.

Provision of Necessary Feeding.

The types of feeding and suitable foods which can be grown on the mixed farm have already been fully dealt with in previous articles, but a farmer is naturally anxious to know approximately what acreages he is likely to require under the different forage and fodder crops and the approximate number of cattle he can carry to the acre on the different types of grazing that are found in the country. In most cases the stock-carrying capacity of the grazing can be very much increased by the provision of forage and fodder crops, since there is not the same need to build up a reserve of grass for the dry season and other adverse periods. Further, such a reserve usually consists only of dry and fibrous material, and is very much better replaced by suitable succulent forage crops.

The wide variation in the stock-carrying capacity of pasture in this country is not always appreciated. Thus, an acre of Kikuyu grass on a forest soil rich in humus, supplemented by an acre of arable crops (principally lucerne and oat hay),

will carry in the neighbourhood of three beasts. On the other hand, the red oat grass veldt situated on an indifferent soil will safely carry about one beast to five or six acres, and even then there is a danger that a certain amount of the oat grass will become trodden out to the coarse *Pennisetum* stage. In intermediate areas, particularly on land where star grass (*Cynodon* sp.) flourishes, the carrying capacity is also exceptionally high, and would approach that of Kikuyu grass were it not for the fact that the dry season is usually acute in such districts. For this reason it is probably not safe to allow for more than one beast to two acres, supplemented by the necessary forage crops.

The carrying capacity of exotic grasses such as Australian Rhodes grass is also high, and in areas of average rainfall will probably amount to one beast to one and a half acres. On the larger farm therefore the policy will probably be that milking animals and rearing stock are grazed on intensively paddocked land close to the homestead (in cases where paddocking leads to improved grazing); alternatively, on grasses planted or sown for the purpose, while the off-laid, dry stock, steers, etc., will be ranched out under more extensive grazing conditions. Even under fairly extensive ranching conditions, provision should always be made for heavy milking animals and young rearing stock, so that these do not have to walk long distances daily for their food. Improved grazing and the provision of forage and fodder crops will to a large extent obviate this, but stress should be laid on the fact that many districts that are described as being suitable only for cattle ranching, particularly in the high-altitude areas, have acquired this reputation simply on account of lack of provision of forage and concentrated foods, most of which could be grown on the farm. The result is that young stock grow slowly, and a cow, although possibly inherently capable of producing a high milk yield, is unable to do so owing to the long distance she has to cover daily, infrequent access to water, and the fibrous nature of the food at certain seasons of the year.

On the arable farm, where one of the chief uses of the cattle is to restore fertility to worn-out lands, the animals will be grazed on reverted arable lands or on arable lands which have been sown or planted down to grass. In many cases the carrying capacity of such lands will far exceed that of the indigenous veldt, and will not be so fibrous in nature, since the herbage will contain a high percentage of legumes or low-growing stoloniferous grasses. An example of this is to be seen in the Njoro district, where the stock-carrying capacity of reverted arable land is about twice that of the indigenous veldt, besides being more palatable to cattle and responding more readily to heavy grazing.

With regard to forage crops and the approximate acreages required, the following figures may prove to be useful. The figures are only approximate, and will of course vary widely from district to district:—

Maize for silage: 10 tons per acre of silage.

Oats and peas for silage: 8 tons per acre of silage.

Oat hay: 2 or 3 tons per acre.

Veldt hay (Red Oat grass, veldt): 6 to 15 cwt. per acre.

Napier grass (green): 10 to 15 tons per acre for cutting.

Kales (marrow stems), whole plant cut to within six inches of ground: 15 to 30 tons per acre.

Lucerne, yield of hay per acre unirrigated (favourable conditions): 4 to 6 tons per acre.

Lucerne, irrigated: 6 to 10 tons per acre.

Hubam clover (green weight): 11 tons per acre.

Thus an acre of a silage crop yielding ten tons per acre, where the amount fed averages 15 lb. daily, taking into account milking stock (up to 30 lb.), rearing stock, etc., will last 50 head of cattle 30 days, or four weeks, allowing for the wastage entailed in feeding.

Similarly, an acre of Napier grass yielding 15 tons per cutting will last 50 head of cattle for three weeks if they are being fed 30 lb. daily. In this connection it should be remembered that the wastage entailed in feeding such crops which, if fed long, may amount to 25 per cent of the total bulk, can be much reduced by chaffing prior to feeding.

In addition, the provision of concentrated foods should not be neglected, since these will be required for calf feeding and for the higher-yielding milking stock. Of protein-rich concentrated foods that can be grown on the farm are linseed, peas and horse beans, all or one of which can be grown in most areas, while of starchy foods a very large variety, including maize, barley, oats, are suitable.

Whilst the expense of concentrated foods is not likely to be justified if native cattle have been used as the original foundation stock, yet such feeding will be necessary for the calves in order to provide the frame and barrel which is necessary for a future heavy milker. Concentrate feeding will also be necessary for high-yielding cows to maintain their condition and milk yield throughout the lactation.

It is very important to emphasize at this stage that unless attention can be paid to the provision of adequate feeding supplementary to grazing, it is of little value to invest any appreciable sum of money in the purchase of stock capable of giving high yields, for they will either "milk off their backs", thereby losing constituting and condition, or they will fail to give the yields of which they are genetically capable.

One of the chief causes of the so-called deterioration of stock in Kenya and the loss of bone and constitution is probably inadequate supplementary feeding. A farmer therefore who is aiming at a herd of forty milking cows, together with attendant dry and rearing stock, say, a total of eighty head, should be provided with forage crops, in addition to grazing, on the following lines:—

A.—Arable Farm, 6,000-7,000 *feet.*

	Acres.
Silage crop, maize (10 tons silage per acre), i.e. 15 lb. per head daily for 150 days	8
Napier grass, one cutting, 10 tons per acre, at 10 lb. per head daily, lasts 28 days	10
Oats for hay, 16 tons, at 5 lb. per head, lasts 90 days	8
	26

When lucerne can be grown successfully this figure may be reduced considerably, and where irrigation is possible it is not necessary to devote such a large acreage to silage, although a reserve of this latter is always invaluable in case of some unexpected occurrence, and it can of course be stored over a long period.

In addition to the land devoted to growing forage crops, a further acreage would be required for concentrated foods, and with the aid of this it should be possible, provided the quality of the grazing is satisfactory, to maintain a herd

average of 500 gallons with very little expenditure on purchased concentrated foods.

The land required for this purpose will be as follows:—

Crop.	Yield per Acre.	Acreage.
Maize	8 bags	6
Barley	6 bags	4
Peas	3 bags	7
Linseed	3 bags	4
		21

This would render available approximately 55 lb. daily of a concentrated mixture suited for calves, milking cows, etc. Depending on concentrates, it may be desirable to eliminate the 11 acres devoted to growing protein-rich foods (peas and linseed), for these can usually be replaced fairly cheaply by purchased oil cakes.

Thus 36 to 47 acres of average arable land would be required to maintain such a herd in an area subject to a prolonged dry season. Obviously this acreage will not be required to start with, since the herd average will probably be low and most of the milk can be produced off grass. At first, little more is needed than an acreage under silage crops for the dry season, and a certain amount of hay, either cut off the veldt or from an oat crop, and a small acreage of concentrated foods, such as linseed and maize, for calves and cows in poor condition.

The planting of an acreage of Napier grass in such an area is always desirable, since, if not required for cutting, it can be grazed off. The above figures may seem to be large, but for the small farm, where a high herd average must be attained in order to produce a high output per acre, it will ultimately be necessary to make provision somewhat on these lines, although this will not be necessary at the beginning of the dairy enterprise.

B.—High Altitude Red Oat Grass Veldt.
(Total, 80 head of stock.)

1. *Roughages.*

	Acres.
Veldt hay, 8 cwt., 4 tons	10
Green soiling, silage (oat mixture), 8 tons per acre silage	10
Oats for hay, at 2 tons = 10 tons at 5 lb. per day = 56 days	5
Total arable ...	15

2. *Concentrates.*

	Acres.
Oats at 8 bags per acre	6
Barley at 8 bags per acre	4
Linseed at 3 bags per acre	7
	17

This would provide approximately 45 lb. daily of a concentrate mixture suitable for feeding to young stock and the heavier milking animals.

Further, all the crops suggested would be suitable in rotation with the existing arable crops. Approximately 32 acres of arable land would be required under these conditions, and since such farms are usually fairly large, it is not probable that such high herd averages would be aimed at as in the case previously cited. The acreage under foods suitable for concentrated feeding could of course be increased as the herd improved; alternatively, a certain amount of protein-rich concentrates could be purchased and supplemented with cheaper home-grown starchy foods.

HERD MANAGEMENT.

1. *Herding.*—In many cases, or on large farms, it will not be possible to provide adequate fencing at the outset so as to render it unnecessary to herd the cattle; it is, therefore, perhaps worth while paying some attention to this point.

The tendency of the native herdsman is to collect all his animals together in a

bunch, and if one strays away slightly it is immediately driven back into the herd; usually the native trains them to respond to a call if they attempt to stray from the mob. Cattle are naturally selective animals in their grazing, and should be as little restricted in their movements as possible while grazing, particularly under ranching conditions, when they are feeding over large areas containing perhaps coarse and under-grazed grass. The herdsman should therefore be encouraged to allow his cattle to graze with no more interference than is necessary to prevent them from straying far.

2. *Water.*—Another important feature in management is arranging that the milking herd can have frequent access to water; a three-gallon cow should be able to drink three times daily, and it is of course preferable if water can be available at all times. Dry stock, heifers and cows, should therefore be grazed on any parts of the farm where access to water is not easy. The water supply on many farms can be improved by the construction of artificial dams, often at a low cost, if the work is done when the oxen and labour are not otherwise busy. Frequently, however, dams are seen that are dry during the dry season, when they are often most needed to increase the extent of the grazing. Although this may be due to failure to secure an adequate depth of water or failure to make the dam watertight, yet it is probable that in many cases the loss due to evaporation is very great. This can be counteracted, to a certain extent, by the planting of suitable trees round the dam so as to create a more humid atmosphere above it, and so lessen the evaporation. In some countries it is even found expedient to use roughly constructed rafts covered with grass and floating on the surface of the water, thereby reducing the evaporation. Attention to such details may very largely increase the stock-carrying capacity of a farm and the availability of its grazing.

3. *Shelter.*—In the higher and colder areas of the Colony the importance of shelter for the cattle is not always appreciated. Driving rain and cold winds will appreciably lower the milk yields of the better type of animal. In most cases these difficulties could be overcome by the planting of suitable windbreaks so as to deflect the cold winds upwards and provide shelter. This object is most readily attained by planting three layers of species of trees, the shortest growing being on the windward side and the tallest on the leeward side, so that the wind is deflected upwards and shelter and warmth are provided. An example of one recommended by the Forest Department for high altitudes is as follows:—

Three rows Cedar, 5 ft. x 5 ft.
Two rows *Cupressus macrocarpa*, 10 ft. x 10 ft.
Three rows *Eucalyptus saligna*, 10 ft. x 12 ft.
Total width of windbreak: 60 ft.

Windbreaks not only protect stock, but also lessen the evaporation from the soil in the dry season; thus the herbage tends to remain greener and more palatable. The provision of rough, grass-roofed hovels in paddocks for young stock should also be considered in these high and colder areas.

At the lower altitudes, under hot conditions, herd owners frequently state that it is necessary to breed dark-skinned stock as much as possible in order to protect the animals from the effects of the sun's rays. In many cases this is necessary owing to the lack of provision of suitable shade trees for the animals, and this is likely to become a problem of some little importance in the future when reverted arable lands, from which all indigenous

trees have of course been cleared, are being increasingly used for grazing stock. In such cases the planting of quick-growing exotic trees, or building cheap, grass open-sided hovels in the fields, is extremely desirable.

A little expenditure on the planting of windbreaks, shade trees, hovels for sheltering calves, etc., is very much better justified in most cases than heavy capital expenditure on elaborate permanent buildings. Trials of suitable shade trees and windbreaks are being carried out, and it is therefore possible to recommend trees suited for these purposes.

Capital Expenditure.

While it is difficult to assess any exact figure, it would appear that the sum of £500 will enable a farmer to start dairying with the expectation of obtaining a return within a fairly short period. The figures quoted below suggest how this sum might be expended.

A.—Commencement with Medium Grade Heifers.

	£	s.
Construction of dip	70	0
Construction of bails, movable calf pens, dairy, etc.	30	0
Dairy utensils (separator, churns, buckets)	25	0
Purchase of 35 in-calf heifers at £7/10	262	10
Purchase of bull	40	0
Veterinary inoculation fees and sundry expenses	9	10
Fencing and tree planting ...	50	0
Herding and labour for 3 months	5	0
Cultivation and planting of forage crops	5	0
Bone meal, salt, etc., for 3 months	3	0
	£500	0

From such heifers, it might be assumed that 30 calved satisfactorily, and therefore in four to five months after purchase 20 gallons of milk should be obtained daily (in addition to the feeding of the calves), which should yield a return of approximately £9 per month, based on butterfat prices at 75 cents per pound. In this manner a cash return is obtained soon after the enterprise has been commenced. Great stress must, however, be laid on the fact that the conditions described above are somewhat hypothetical, and it might at the present time be difficult to buy the heifers required. In the case of a farm in a dirty area, or if difficulty was experienced in buying grade heifers, it might be necessary to start with native stock, from which the return would be very low, and would scarcely pay out-of-pocket expenses for a period of nearly four years after the herd had been started, when the grade progeny would be calving down.

B.—Commencement with Native Stock.

	£
Dip, buildings, calf pens and utensils, etc., as before	125
Purchase of bull	40
Veterinary fees and sundries ...	10
Fencing, etc.	80
Purchase of 50 native heifers in-calf at £4	200
Herding and labour (including transport) for three months	5
Bone meal, salt, etc., for 8 months ...	5
	£465

It may be assumed that of the 50 native heifers purchased at least 15 would probably be too poor milkers to be worth using as foundation stock, and would be culled out, or perhaps some of these would not be in calf. It is very difficult even for a man who has had long experience with them to judge the value of native heifers when buying, whereas with grade stock there are usually indications which are fairly reliable guides as to the possible future capabilities of the animal. The purchaser must therefore be

prepared to cull a very large number of native heifers from the start.

It is almost impossible to assess the return that is likely to be obtained from this native stock, but it can be assumed that it will in most cases do little more than pay out-of-pocket expenditure.

Purchase of Stock.

The purchase of a bull is an extremely important item, and some farmers would possibly consider the purchase of an adult grade bull to use temporarily, buying meanwhile a small pure-bred bull calf, aged a few weeks only, to rear themselves, arguing that this was cheaper than buying an adult pure-bred bull ready to use at once. It must, however, be remembered that such a policy will delay the improvement of the stock, and that it is far better to commence with the pure-bred animal which will tend to throw progeny of one type. It might be possible to buy an old bull from a neighbour, who wished to sell in order to avoid inbreeding. It is always best, where possible, to buy a proven sire, and it is a pity in this country that very few sires are kept long enough to know the milk records of their progeny. A bull should always be purchased on the strength of his dam's milk record and the records of his sire's antecedents, rather than purely on his pedigree, and, in the case of an old bull, on the records of his progeny.

When purchasing grade heifers, it is of importance to buy animals either known to be in calf or else too young for service. There is much controversy as to the correct age at which heifers should be put to the bull, and many farmers aim at 18 months, allowing them if necessary a fairly long dry period between the first and second lactations. There is no doubt that if they are served at this younger age they are easier to get into calf, and, provided due attention has been paid to feeding as calves, no harm is likely to result. This practice is probably advisable more particularly in the lower-altitude, quicker-growing cattle areas. When purchasing heifers attention must be paid to such characters as spring of rib, depth of body, and size of barrel, since the cow that lacks these obvious signs of constitution is unlikely to be a heavy milker or good feeder. If older grade cattle are being purchased, then attention should be paid to the development of the milk veins and the milk wells, and also of the bag itself. It is a common failing of grade cattle, probably inherited from native cattle, that the bag is cut away very badly, and not carried well forward and back between the hind legs.

It will generally be noticed that cattle that are purchased from the high-altitude areas, where growth is normally rather slow, unless they have been well hand fed as calves, will grow out very well in the lower-altitude areas with better grazing, such as star grasses, etc. It should be remembered that it is always advisable to move cattle from poorer conditions to better, provided that the conditions have not been such as to stunt them in their youth.

Conclusion.

A capital sum of £500 should enable a farmer situated in a dirty area to commence dairying on an economical scale, even at the present prices of stock, which are very much higher than those prevailing in the past few years, and are probably rather higher than the prevailing prices of butterfat make justifiable. In a clean area, where expenditure on a dip and fencing may not be immediately necessary (though nearly always desirable, owing to the danger of bringing infection on to the farm with purchased stock), the initial capital outlay may be

slightly less. In many cases the original capital will have been borrowed. In an area which is dirty, and where it has only been possible to start with native stock and a pure-bred bull until the land has been cleaned up, it will be difficult to pay interest on the borrowed money for a period of four years until the cross-bred offspring themselves calve. In such cases a moratorium on the loan for this length of time would be extremely desirable.

The advantages of dairying may briefly be summed up thus: It brings in a monthly, regular, and almost certain cash income, so that money is being turned over the whole time; working expenses are low, and further the labour requirement is low compared with arable farming; and it employs for the most part natives of pastoral tribes who do not readily take to agriculture.

In the arable areas the use of cattle is essential for the restoration of fertility to worn-out arable lands or to graze reverted arable lands in order to obtain a return on capital invested in the land which would otherwise be idle.

Waterproofing Cements*

According to an Australian contemporary, a method for making cement waterproof which has been largely tested may be used for coating tanks and troughing. Use one part cement, two parts sand, three-quarters of a pound of dry powdered alum to each cubic foot of sand. Mix the sand, alum and cement dry, and add water to which three-quarters of a pound of soap to each gallon has been dissolved. This mixture may be used for stopping leaks in concrete tanks or troughs, and may also be used for closing leaks in metal tanks. Use two plates, one on each side of the leak, drawn together by bolt and nut, enclosing some of the mixture between the plates.

For the purpose of waterproofing concrete there is nothing better than the commercial waterglass, which is a solution of sodium silicate. Dilute the waterglass with four parts of soft water; apply with a flat brush, thoroughly wetting the surface. The waterglass may be coloured by mineral pigments if desired, thus at the same time forming a waterproof colour for concrete.

*_The Farmer's Weekly_, 7th October, 1936.

Pseudococcus kenyae (Le P.) and Climate

By F. B. NOTLEY, *Entomologist, Department of Agriculture, Kenya.*

During the last few years a change has come over the position of *P. kenyae* as a pest in the Central Province of Kenya. Whereas previously it had seemed that the epidemic species of mealy bug was gradually spreading into new districts, in any of which it might again produce the alarming outbreaks of earlier years, it now appears that it has already reached the limits of its spread in the Central Province.

If we accept the theory that *P. kenyae* is an insect introduced to the Central Province—a theory which has not been seriously questioned—then the development of the outbreak may be said to have followed classic lines. The first outbreaks, which were very severe, occurred in Thika. From thence infestation spread rapidly throughout Kiambu, Ruiru and Thika, and after a considerable time crossed natural barriers and entered Ngong, Nyeri, and Makuyu. The severity of these outbreaks diminished with the use of grease-banding against the ants, and the natural increase of indigenous predators, particularly *Coccinellidae,* which followed the vast increase in their food supply from the development of *P. kenyae.* The enormous *Coccinellid* populations of coffee plantations in the mealy-bug areas are most striking when compared with those of Nyanza Province or Uganda.

As regards the Central Province then, *P. kenyae* appears to have penetrated wherever coffee is grown, and its status as a pest varies from season to season, according to variations in climate as they affect in turn the mealy bug or its predators. The losses from mealy bug are severe, but are not likely to show any continued increase or decrease until some new factor is introduced.

Latterly, *P. kenyae* has been identified from Uganda and Bukoba, and a recent survey in connection with the introduction of parasites has shown that it is spread throughout Uganda (with the possible exception of Bugishu), throughout the whole of which area its status is that of a minor pest. The same appears to apply to Bukoba.

In the Central Province the severity of *P. kenyae* outbreaks can be graded fairly accurately with altitude. No coffee is grown below 4,500 feet. From 4,500 feet to 5,000 feet (Makuyu, Lower Thika), outbreaks are most severe; from 5,000 feet to 5,500 feet (Thika, most of Ruiru, Lower Kiambu) outbreaks are severe, while above 5,500 feet outbreaks in normal years are slight.

It may therefore be supposed that the differences in status of mealy bug as a pest in this area are due to differences in temperature, the mealy bug itself becoming more active and reproducing more rapidly the lower the altitude. Temperature, which is bound up with altitude, seems to be the most probable factor which is influencing the situation, although humidity may play its part.

If temperature were the important factor, however, we might expect, at first glance, to find that coffee in Uganda, which is grown at altitudes ranging down to 4,000 feet, would be severely attacked. It has been seen in Uganda that mealy bug attacks *robusta* coffee just as severely as *arabica* growing under the same conditions. If the tentative conclusions put forward in my report on mealy bug in Uganda are correct, namely, that

mealy bug in Uganda is not controlled by more efficient predators or parasites than in Kenya, then the alternative must be accepted, that just as mealy bug fails to develop quickly enough in the higher areas of the Central Province to become a pest, so mealy bug is failing to develop quickly enough under Uganda conditions to become a pest, despite the higher mean temperatures of Uganda.

It has also been found that the most important of its parasites in Uganda, none of which exercises any considerable control, is *Amagyrus aurantifrons* Comp., which is present all over Kenya on *Pseudococcus filamentosus;* and, further, that while the resistance of *P. kenyae* to this parasite in Uganda is high, as shown by the presence of phagacitosed eggs and larvæ, in Kenya it appears to be almost complete, though *Amagyrus* has been bred on *P. kenyae* in Kenya on mealy bugs which were dying of starvation. The reduced resistance of *P. kenyae* to *Amagyrus aurantifrons* in Uganda suggests that *P. kenyae* is growing under less favourable conditions there than in Kenya, and it may be that this lowered resistance to non-specific parasites also means a lowered vitality and reproductive rate.

It must be admitted that the mean temperatures experienced in various parts of Uganda appear to be suitable for the development of *P. kenyae* as a pest. But several climatic factors will probably be very different in Uganda and Kenya. The first is humidity. There is a marked difference in humidity between the Central Province and the whole area influenced by the Lake, where the climate is markedly more humid. It is possible that atmospheric humidity may have a very large influence on the reproductive rate of *P. kenyae*; preliminary experiments in the laboratory have suggested that this is so, and Dr. Betrem has reported similarly for another species of mealy bug in Java (R.A.E., Vol. 23, A., p.12).

Secondly, the diurnal range of temperature at, for instance, Nairobi is very much greater than that of, say, Kampala, and hence, although the mean temperature of Nairobi may be lower than that of Kampala, the average monthly maxima at Nairobi are very little different from those at Kampala. In estimating the effect of temperature on an insect by the summation of effective temperatures, maximum temperatures may be very important.

Thirdly, there is the interpretation of screen temperatures in terms of temperatures in the coffee bush. Kirkpatrick has shown that cloudiness (associated usually with high humidity) not only depresses the maximum screen temperature, but also reduces the amount by which the maximum temperature in the coffee bush exceeds that in the screen.

A consideration of all these factors suggests the possibility that the effective temperatures experienced by an insect in a coffee bush in Uganda may be considerably lower than those to which an insect is exposed in a similar bush in the Central Province of Kenya. As yet no direct evidence is available on this point, but it is interesting to note that an insect such as Thrips, outbreaks of which have been correlated with high temperature, causes severe damage in the mealy-bug areas of Kenya but none in Uganda.

It is necessary here, however, to examine a view put forward that mealy-bug outbreaks in Kenya are due to unfavourable soil conditions. First of all, there appears to be no striking correlation in Kenya between mealy-bug incidence and poor soils: a great deal of work, in fact, has as yet failed to show any such correlation. Further the logical conclusion

of the argument seems to be that, since nearly the whole of our main coffee-growing area suffers from mealy bug, all the soil in that area is worse than the worst soil in Uganda. Since this is absurd, the hypothesis is put forward that some undetermined minor element may be absent from the soil of the Central Province, a parallel case being "tea yellowing" in Nyasaland. It appears to me that to build such a hypothesis on the presence of an insect pest when no other symptom in the plant itself has been noted is unnecessary until all other possibilities have been exhausted. The hypothesis also takes no account of the evidence which has been accumulated that *P. kenyae* is not indigenous to the Central Province.

There seems no doubt that outbreaks of *P. kenyae* in Uganda are correlated with poor soils and unshaded coffee, but in Kenya mealy bugs appear to increase most rapidly on plants which are in good health and bearing a young crop. It is conceivable that in Uganda it is only in a tree which is unshaded and in poor leaf owing to poor soil that sufficiently high temperatures or low humidities, or both, are recorded to encourage an outbreak of mealy bug, whilst in the Central Province the climate is almost always favourable, but intense outbreaks only occur when a third encouraging factor, an ample supply of suitable food provided by the tree for the developing flower or fruit, is available.

All the above suggestions are highly speculative, and are only written in the hope that they may encourage the study of the eco-climates of the coffee tree, and the effect of such eco-climates on *P. kenyae*. A knowledge of the climatic requirements of this insect might not only suggest a method of combating mealy bug, by altering the eco-climate of the plantation, but would also show whether our fears of *P. kenyae* being introduced to areas from which it is at present absent are justified.

Kenya Coffee

A Graphic Analysis of post war Prices

By V. LIVERSAGE, *B.Sc., M.S. (Wis.), N.D.A., Agricultural Economist, Dept. of Agriculture, Kenya.*

Price movements are often bewildering even to those whose livelihood depends on them. People in the trade commonly ascribe contemporary movements to causes that on a historical view are inadequate to explain them. In some quarters physical supply and demand are credited with more importance than they deserve; in others, the psychology of the market tends to overshadow the ultimate causes by which it is determined.

In order to understand contemporary price movements it is essential to give close attention to the way in which prices have moved in the past and to correlate these movements with concurrent events in the economic world. The history of price movements cannot be easily seen without representing them pictorially by means of a graph. Even then the resulting graph may appear so complicated as to preclude the formulation of any practical conclusions.

Take, for instance, the graph in Fig. 1 and confine attention for the moment to the continuous line representing prices of Kenya coffee in London. At first sight, there is seen a confusion of long and short period movements which present an erratic appearance.

The methods of statistics can be used to dissipate most of this confusion by analysing the price movements into their constituent elements. If the results do not always amount to actual proof they at least suggest possible or probable explanations. A more important effect is that they give a more balanced view of the movements and avoid some misconceptions. In this and subsequent articles an attempt is made to show in graphic form the component influences that have entered into the determination of the general course of price of Kenya coffee in London during the period 1922 to 1935.

What conclusions can be drawn from Fig. 1? There seems to have been a jump in the price of Kenya coffee from 1922 to the end of 1924. Subsequently, the general course has been downward. What is the cause of this? Was the supply short relative to demand previous to the end of 1924? Has the bottom dropped out of the market since then? If so, is it due to increased supply or reduced demand? Has the change occurred in the supply and demand ratio for mild coffees, or have the mild coffees been swept in the vortex of Brazilian? What is the meaning of the frequent short-period up-and-down movements of Kenya coffee prices? Finally, to what extent have prices been affected by factors extrinsic to the coffee industry?

Before any attempt can be made to answer these questions, the price movements must be analysed. In examining Fig. 1 it will be seen that the short-period fluctuations exhibit a more or less regular periodicity, each phase extending over a year. The factor concerned is a seasonal variation. This can be removed by appropriate statistical treatment. The course of prices, unobscured by seasonal variations, is shown in Fig. 2.*

* Seasonal variation removed by taking a twelve-month moving average centred (this prevents the continuation of the graph to the ends of the period covered by the figures used).

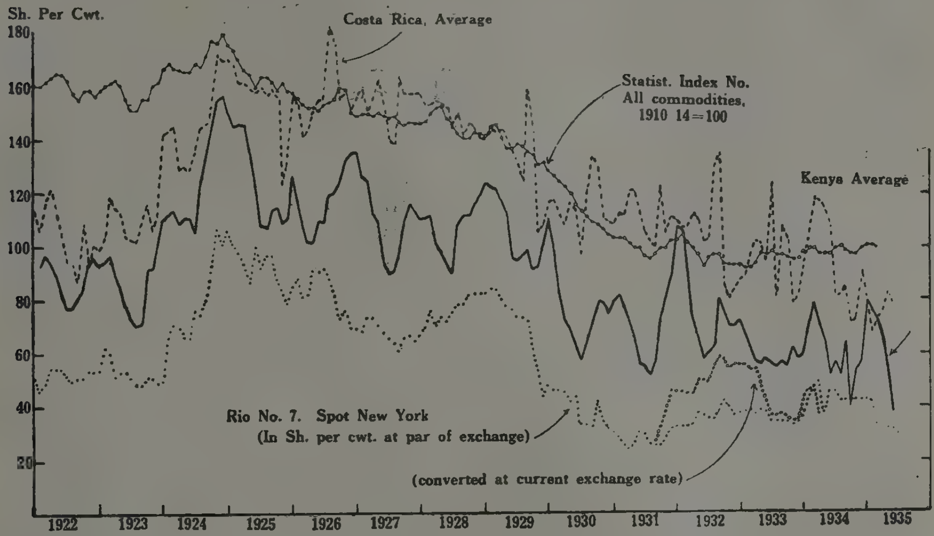

FIG. 1

Prices of Kenya and Costa Rica Coffee in London with comparison with Rio No. 7 in New York and with general wholesale prices

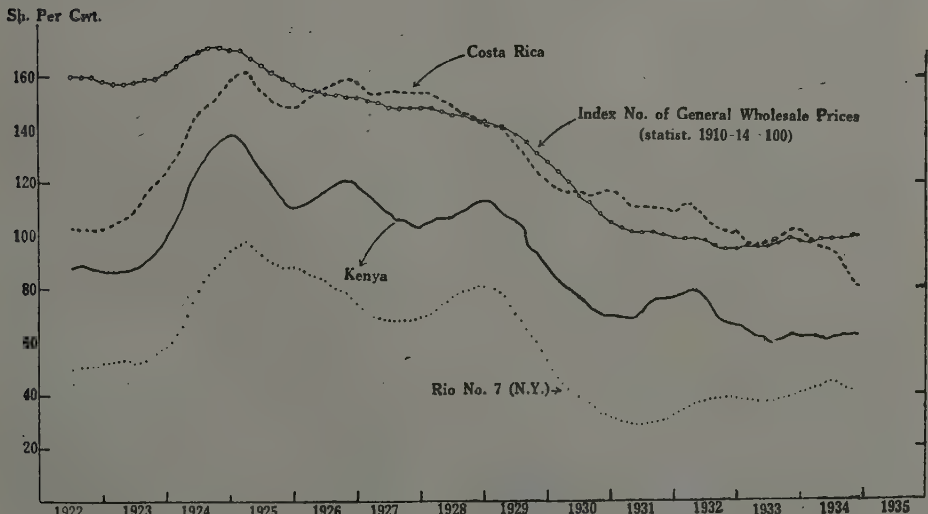

FIG. 2

Prices of Coffee and general wholesale Prices compared. Seasonal variation removed.

In the broad movements over the period as a whole, two kinds of movement are still combined. Firstly, there is a long-time change, which is spoken of as the secular trend and represents a more or less steady and permanent change in the general position. Secondarly, there are up-and-down movements extending over periods of three or four years; these are spoken of as cyclical movements, and may be compared in some respects to the "business cycle" in secondary industries.

For the present the cyclical movements will be neglected, and all movements other than the seasonal variation spoken of as the trend. It will be seen that both in Fig. 1 and Fig. 2 a line is inserted depicting the general level of wholesale prices.† The comparison thus afforded is a most important one, showing the degree to which coffee prices have moved in response to changes in the value of money (in terms of wholesale commodities). Obviously there is a vast difference between a change in price due to a change in the unit in which the price is expressed, and one reckoned in a unit of constant value.

In Fig. 2 it is seen that in 1922 coffee prices had fallen well below wholesale prices in general and that between 1922 and the beginning of 1925 they moved rapidly up towards the general index. From that point the broad movements are closely similar, so much so that it is difficult to escape the conclusion that the monetary factor has been the chief influence at work.

Now the price of coffee may be very important to growers, even if it is due in large measure to the value of money, but in some respects our judgments must be influenced profoundly by the nature of the causes which produce the effect. A fall in price due to monetary causes will not be corrected in the course of a season or two by corresponding falls in wages, interest, transport costs, etc. On the other hand, it may be less permanent than a fall due to an increase in the productive capacity of the industry.

It will be of value, then, to remove the effect of change in the purchasing power of money from the price movements, and to show them as they would appear if expressed in a monetary unit of constant value. Fig. 3 shows the prices of coffee as they appear when expressed in terms of a shilling having the (wholesale) purchasing power of the pre-war (1910-14) shilling.

We are now for the first time in a position to appreciate the real movements of coffee prices. Two facts immediately emerge. The first is that the value of coffee has been much more steady in reality than uncorrected prices would indicate. The value of all three types was higher at the end of the period than at the beginning. A rapid rise took place until the end of 1924. Since that date there has been some decline in Kenya and Rio, but it is only since 1933 that a general decline in Costa Rica is discernible. The interpretation to be placed upon the graph depends largely on how the low period 1922-24 is regarded in comparison with the period of higher values which followed. Here it is necessary to take a longer view, and later studies may here be anticipated by saying that there is ~~good~~ reason to regard 1922-24 as an abnormally low-price period and 1924-28 as an abnormally high-price period. The writer's conclusion is that, in spite of an increase in production, both of Brazilian and of mild coffees, since 1922, there is no evidence of any appreciable decline in the basic value of coffee on the world's markets. Readers will appreciate the great significance of this conclusion.

† Statist index number converted to base 1910-14 equals 100 shillings.

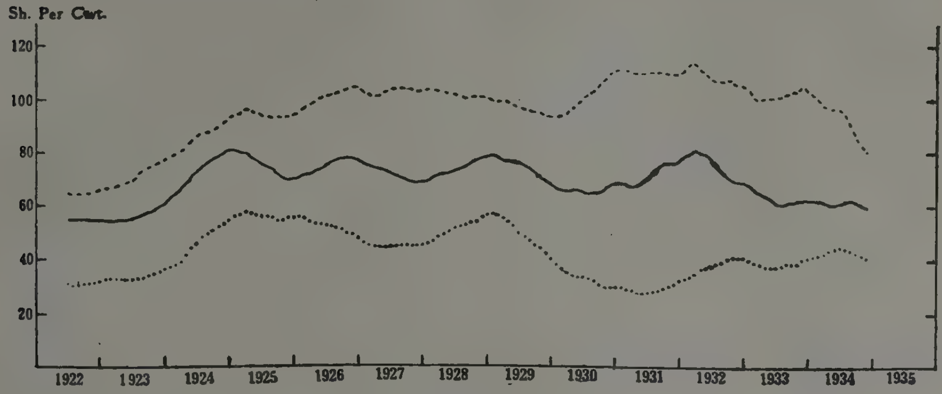

FIG. 3

Prices of Costa Rica and Kenya Coffees in London and Rio. No. 7 in New York.
In terms of 1910-14 wholesale prices.

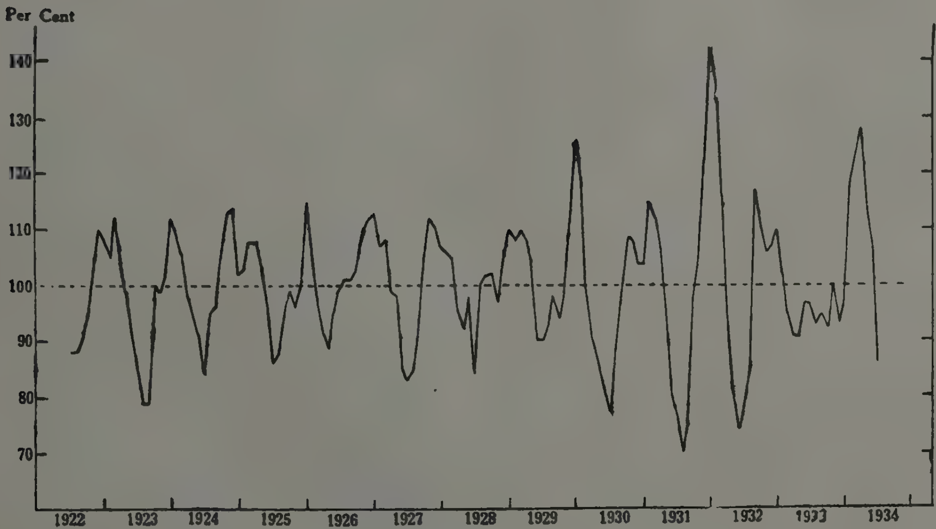

FIG. 4

Prices of Kenya Coffee

Percentage fluctuations about the trend (12-month moving average centred).

The second fact which emerges is that a considerable degree of sympathy is shown between the movements of Kenya and Costa Rica in London and Rio No. 7 in New York. They rise together from the beginning of 1922 to the end of 1924. Peaks in all three curves appear more or less simultaneously at the beginning of 1925, the end of 1926, the beginning of 1929 and the middle of 1932. All three curves decline during the first half of 1933, steady again, and rise slightly in 1933, and decline in 1934.

The comparison is the more significant when it is realized that the prices of Rio No. 7 are spot New York (dollar) quotations converted at par of exchange, and thus independent of sterling movements, while those of Costa Rica and Kenya are sterling prices on the London market.

During the period as a whole the exchange between London and New York did not vary far enough outside the "gold points" to affect the appearance of the graph in Fig. 1, but during the period from September, 1931, to the end of 1933 there was a considerable movement in favour of the dollar. Whereas in September, 1931, the rate was 4.86, in October it dropped to 3.86, in November to 3.75, and in December to 3.35. It was not until July, 1933, that a sustained rise set in, and not until November of the same year that it again reached par. Since that date it has been generally somewhat above par. From Fig. 1, where Rio No. 7 is expressed both at par of exchange and after conversion at the current rate, it would appear that Kenya and Costa Rica coffees in London show a closer relation to dollar than to sterling prices of Brazilian; in other words, that they fail to follow devaluation to its full extent. The reason for this is not clear to the writer, but as the period of exchange divergence was relatively short it is perhaps unwise to attach much importance to the observation.

One point of detail should be noticed in passing. There has been some tendency recently for a portion of the Kenya crop to be consigned direct to markets other than the United Kingdom, and since the finer coffees naturally gravitate towards London this must influence the interpretation to be placed upon average London prices. The following figures show the position so far as particulars are available:—

	I Total Exports	II Difference between Cols. I and III	III Imports into the United Kingdom	IV Difference between Cols. III and V	V Re-exports from United Kingdom
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
1930	310,168 (100)	59,799 (19)	250,369 (81)	131,761 (43)	118,608 (38)
1931	245,991 (100)	17,061 (7)	228,930 (93)	76,913 (31)	152,017 (62)
1932	276,041 (100)	48,234 (17)	227,807 (83)	165,350 (60)	62,457 (23)
1933	257,214 (100)	34,799 (14)	222,415 (86)	134,436 (52)	87,979 (34)
1934	187,017 (100)	93,984 (50)	93,033 (50)	42,024 (23)	51,009 (27)

Column I from Agricultural Census.

Columns III and V from figures supplied by H.M. Commissioner, East African Trade and Dependencies Office, London.

The figures given in brackets show the quantities in Columns II to V expressed as percentages of the total exports in Column I. Allowance must be made for the ordinary time lag between shipment from Mombasa and arrival in the United Kingdom.

The percentages given in brackets in Column II show a sudden spurt in 1934. It is possible that but for this the sharp drop in Costa Rica prices in that year would have been paralleled in the case of Kenya.

It is hoped in a subsequent article to trace the connection between supplies of coffee and other special factors and the price movements shown in Fig. 3. In the meantime, attention is turned to a particular manifestation of the movements in the case of Kenya coffee.

In coffee circles confidence is annually at a low ebb in the middle of the calendar year and revives towards the end. This is due to a lack of appreciation of the normal seasonal variation in prices and neglect to correlate current prices with those for the same period in other years. Fig. 4 shows the way in which monthly prices of Kenya coffee fluctuate about the average values.* A regular periodicity of up-and-down movements is seen, with a noticeable increase in amplitude from the 1929-30 season onwards. In each season prices reach a peak during the months January-March, and a low point about July. Presumably this is due to variations in quality—coffee picked in the height of the season being superior. It is possible that a partial explanation is the appearance on the market of coffee from different districts. It has even been suggested that buyers will pay a high price in February for Kenya coffee in which they would not be interested in August; in other words, that the market is influenced by preconceptions on the part of buyers. Whatever the cause, it is quite evident that pessimism in the middle of the year may be quite groundless unless prices are considered in relation to the normal seasonal cycle.

A generalized version of the seasonal cycle, based on the years 1922-1935, is shown in Fig. 5. As compared with the general level of prices of Kenya coffee at the time it will be seen that on the average prices rise from 86 (normal = 100) in July to 108 in December, and 111 in January and February, falling again to 108 in March, 100 in April, and 86 in July.

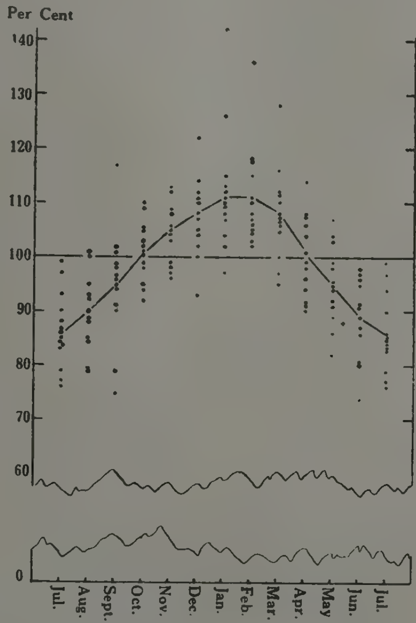

FIG. 5

Seasonal variations of Prices of Kenya Coffee in London.

Percentage variations from trend-line (calculated by 12-month moving average, centred). Trend values = 100. The continuous curve is a generalized seasonal curve for the individual values shown by dots.)

*The actual monthly prices are shown in the graph as percentages of the value for the same month in Fig. 2.

The Influence of Forests on Climate and Water Supply in Kenya—Part III.

By J. W. NICHOLSON, *formerly Forest Adviser to the Governments of Kenya and Uganda.*

CHAPTER V.

Forests and Rainfall—in Kenya.

Our study of the influence of forests on rainfall has shown very clearly that it is essential to analyse the nature of the rainfall before attempting to estimate the effect of forests thereon. Firstly one must distinguish between instability and orographical rain, and secondly one must determine the extent to which occult precipitation may occur. As rainfall conditions in Kenya have never been studied scientificially, it is with considerable hesitation that the writer essays to tackle the problem, but such an attempt must be made if we are to proceed any further with our investigation into forest influences. The description of rainfall conditions which is given below is based, partly on observations made personally by the writer, partly on such meteorological data as have been published, and partly on information supplied by various residents in the Colony, official and unofficial, to whom much thanks is due. It is not claimed that the descriptions are absolutely accurate. We must await the future investigations of the new East African Meteorological Service for definite knowledge to become available, but it represents a rough attempt to interpret rainfall phenomena in the light of such facts as have been collected by the writer.

The region in which the main rainfall appears to be of the instability type lies to the west of a line which, starting below the Ngong Hills—(*N.B.*—Conditions to the south-west and west of Ngong have not been investigated.)—follows the foot of the escarpment and then the main Aberdare range to the vicinity of Sattimma. The line then swings east to the lower slopes of Mount Kenya, which it follows round north-eastwards to a point about due north of the peak. From this point it runs north to Mukugodo, whence it swings north-westwards to the Karissia Hills and the Leroghi Plateau. It then runs north-west, striking across the north of the Kamasia range, and eventually following the line of the Suk Hills until their junction with the Karamoja Escarpment at Moroto.

With the exception of areas in the vicinity of the line described, the whole region to the west of the line is characterized by instability rainfall conditions. The rain normally falls in the afternoon and is frequently accompanied by thunder. Monsoon conditions, represented by cloudy days and nights and morning or night rain, do occur at times, but they are rare. The storms generally come from the north-east, but local topographical features may alter this general direction. There is a distinct tendency for storms to follow valleys. December, January and February are the driest months. Except towards the south and in the driest tracts, the rest of the year constitutes more or less one long rainy season with the heaviest fall occurring in April, July and August.*

*We do not know enough to say how far instability rain is influenced or supplemented by the monsoon, but it is likely that the further west one goes the smaller the influence of the monsoon and the more typical and true the instability rainfall conditions. On the border land, instability and monsoon rainfall tends to become mixed up, e.g. on Laikipia, where the April and November monsoons are felt and at the same time July-August instability rainfall occurs. As a rule the border land will enjoy a poor and unreliable rainfall, as the monsoon is too weak to yield much rain and at the same time it inhibits a good instability rainfall.

The reasons for these rainfall conditions would appear to be as follows: The whole of this region is protected by mountain ranges from the influence of the south-east wind, although the influence of the latter may be felt on the border line. It also mostly lies at a considerable altitude, and it thus escapes desert wind influences. The rainfall is affected mainly by the position of the sun and by the influence of the prevailing north-east wind. Normal instability rainfall should be greatest when the sun is overhead, but in East Africa—for some reason not known to the writer—the rainfall is greatest just after the sun has passed north over the equator and just before its passage back. This is in the months of April and August respectively. Strong ground winds inhibit vertical instability currents, and the latter can only operate when the north-east wind loses its strength or when it gets pushed up to higher altitudes. These considerations explain why the December-February rainfall is a low, strong north-east ground wind, and why in the southern parts the June-July fall is less than in the north: the sun is less vertical. A further feature of the instability rainfall is that there appears to be an optimum range of altitude within which the rainfall is greatest. This range is between about 3,000 and 8,000 feet. Above 8,000 feet the absolute humidity of the air is affected by cold; below 3,000 feet the heat of the sun causes a desiccating effect, with the result that air humidity becomes lowered following upon periods of rapid evaporation. A secondary feature of this optimum range is that the actinic rays of the sun also appear to be greater than outside this range or than where monsoon conditions prevail. Compare the relative power of the suns of Kericho and Nairobi as sunstroke agents!

In the previous chapter evidence has been given that forests can increase instability rainfall. What is the evidence in Kenya? It is much more obscure than in Uganda, as the country is mountainous, and rainfall is influenced by topography. If forests increase instability rain, we should expect to get our greatest rainfall in places in the middle or to the immediate south-west of forest areas which receive the maximum protection from the ainfluence of the north-east wind. These conditions are met with at Kericho, Kaimosi and Kakamega, and these are the places which actually enjoy the greatest recorded rainfall in Kenya. Further, in Kericho district the rainfall gets rapidly less as one proceeds southwestwards away from the forest edge. Apart from these facts, there is evidence that, in areas which have been deforested within recent years, such as those round Elburgon and Molo, the rainfall has become less. In view then of the conclusions reached in the preceding chapter, it may be accepted that forests increase instability rainfall in Kenya. It should be added, however, that at very high altitudes, where evaporation is less rapid and the relative humidity of the air higher, it is possible that the effect of forests on rainfall is relatively less than at lower altitudes, as at such greener altitudes other forms of vegetation can contribute almost as much moisture to the air as forest trees. This consideration is not borne out by the writer's observations on Mount Elgon, at an elevation of 10,000 feet, but theoretically it is sound.

In the instability rains region occult precipitation other than dew is small, as the conditions do not permit of enveloping clouds at night.

We can sum up by stating that in the instability region forests influence rain-

fall, and that possibly the lower the altitude the greater the influence. As has been found to be the case in Uganda, the influence of the forests is probably very local. Very extensive forest tracts are therefore not as valuable as smaller and more numerous forest tracts. If forest land has to be disforested for other development purposes, it is preferable that such land should be in the form of strips running north-west—south-east in the middle of extensive forest tracts. It has not been determined what the minimum size of a forest should be in order that it can exercise an influence on rainfall. This will depend on altitude, topography, orientation, composition, density and shape. In normal circumstances, any compact forest area of upwards of 4,000 acres or so in extent should exercise some influence on rainfall. The creation of forests in dry parts of the instability region, such as the Rift Valley, should have a beneficial effect on climate.

In the rest of Kenya, which lies to the north and east of the line described above, the rainfall is of the monsoon type. It is possible that during the non-monsoon months part of the rainfall is of the instability type, but the writer has as yet no proof that such is the case. Should further investigations prove that instability rains are a regular feature of some localities, then it may assumed that the presence of forests will influence such rainfall. The conditions of monsoon rainfall vary. At the coast there is one monsoon, with a maximum fall in May. April and June are next wettest months. The rest of the year is comparatively dry. The rest of the monsoon rainfall region enjoys two monsoons, with the highest falls culminating in April and November. The conditions which bring about this rainfall are not uniform, and to determine the differences we must study winds. There appear to be three prevailing winds. At altitudes over about 5,000 feet, the prevailing wind is north-east, and so far as observations go this direction remains unaltered throughout the year. Below this altitude the prevailing wind is south-east, but it appears to have two different sources. During the monsoon rain months the south-east wind is a trade wind which comes from the ocean. During the remainder of the year the sea coast, so far as is known, is not affected by a south-east wind, and the latter must be a land wind having its origin in Kenya. It reaches its greatest development in the Northern Frontier Province, but it is felt in Machakos, Voi, Kitui, and Meru districts. The probability is that the north-east wind brings little moisture into the country, and where the direction of the rain appears to be north-east the source of the rain is mainly the south-east trade wind. The latter wind pushes up into the north-east winds at altitudes of about 5,000 feet or over, and either gets overcome by the greater strength of the latter or the two unite to form an easterly wind. This mixing of the winds can be watched at places like Mumoni in Kitui and Meru. Most of the rainfall which reaches Nairobi has previously swept over Kitui and become diverted in the neighbourhood of Ol Donyo Sabuk. That the predominating moisture comes from the south-east wind is proved by the fact that the lower south-east slopes of Mount Kenya and of the Igembe range are much wetter than the north-east slopes.

This discussion on winds will help to explain local variations in the conditions of rainfall. In the Northern Frontier Province most of the area is low lying, and according to orographical rainfall laws it cannot get a heavy rainfall. Hill ranges like the Matthews range cannot

get a heavy rainfall except on the higher slopes, because some of the rain coming from the south-east has already been deposited on the Igembe range. The Leroghi and Karissia hills get still less rain, as they in turn are covered by the Matthews range. Marsabit is a lone mountain to which the south-east trade wind has had unimpeded access. The result is a heavy rainfall. (It may be here noted that in the instability region a mountain like Marsabit would receive comparatively less rainfall, as the influence of forest vegetation on rainfall would be dwarfed by the surrounding dry desert conditions.) In districts which are not so remotely situated as the Northern Frontier Province from the sea, and which obtain their rainfall direct from the south-east, i.e. most of Voi, Kitui, Machakos and Meru, the rainfall differs from those, such as Nairobi, Fort Hall and Kiambu, which receive their rainfall from the north-east, in that the "long" rains are during the November monsoon, whereas in the case of the other districts the "long" rains are the April rains. The reason would appear to be this: During December, either the north-east wind or the south-east wind is not as powerful as during May, and therefore those localities which obtain their rain from the north-east will have a lesser rainfall than those obtaining their rainfall from the south-east. This is merely an unproven theory put forward to explain the facts.

It may be assumed that, as in other countries, forests have little direct influence on monsoon rainfall, occult precipitation will vary according to locality and altitude. In those regions where the rainfall is direct and unimpeded from the south-east, forests at an altitude of about 4,500 to 5,000 feet receive considerable occult precipitation as they are enveloped by clouds. Where the prevailing wind is from the north-east occult precipitation occurs at altitudes of about 6,000 feet and upwards. The problem of the extent of occult precipitation can be estimated from a topographical map, but it is best decided for individual localities by personal observation.

Have forests any regional influence on monsoon rainfall in Kenya? It is very difficult to know, particularly as the mixing of the north-east and south-east winds complicates the problem. There has been a deficiency of rainfall at Nairobi for the past five years, but one would require a good deal of imagination to put the deficiency down to vegetation changes. The latter could only influence the Nairobi fall if they had occurred on a considerable scale in the direction of Ol Donyo Sabuk, but so far as is known no such changes have occurred. The deficiency is far more likely to be due to a temporary and local climatic variation. It is possible to argue that forest cover has an adverse regional effect on rainfall. In Kitui district it is said that a good long rains is invariably followed by a late and poor short rains. Now a good long rains means that the district, which is well wooded with trees that lose their leaves, remains greener longer, and therefore that the south-east wind may not be attracted into the north-west parts of the district by heated air rising from the ground and creating a vacuum. Were the district disforested, the south-east wind would not be delayed in its arrival. A delayed rains in Kitui ought to affect Nairobi. Nairobi was certainly affected in 1928, but the writer does not know if it always has been affected by the Kitui rains. Needless to say that a possible adverse regional influence of forests is no argument for their destruction—not, at any rate, in the present

case, as although disforestation might reduce delays in the Nairobi rains, it would probably tend to shorten them.

We may sum up by stating that in the monsoon rainfall region, forests play a minor part in affecting rainfall, except such as induce occult precipitation.

The above description of rainfall conditions in Kenya is admittedly sketchy, and it may possibly prove inaccurate. Many details of variations in rainfall have not been touched upon. Far more theories are necessary to fit all the facts, but we must leave it to professional meteorologists to deal with the intricacies of the subject. From the point of view of forest influences the main point to determine is the extent of instability rainfall, and the writer trusts that future research will prove that his dividing line is not far wrong.

CHAPTER VI.

Forests and Stream Flow: The General Problem.

The subject of the influence of forests on stream flow has in the past been a less debatable one than that of the influence of forests on rainfall. Dr. Brooks, in the paper which has already been quoted from, does not go into the subject in much detail. He sums up as follows: "Afforestation of grass or crop land probably increases the local run-off by ten to twenty per cent, this amount being made up partly by the decreased loss of water in evaporation and transpiration, partly in the slight increase of actual rainfall. This is likely to be the most noticeable effect of afforestation. Afforestation of bare ground would decrease the run-off, but this effect would be marked by the much greater regularity of the flow." Zon goes into the subject in very much greater detail, and he summarizes the effects of forests on run-off according to the topography, soil, and rainfall conditions. His conclusions and data are most valuable, but in the writer's opinion he does not consider all the factors which influence the problem, and in the presentation of the subject which is given below the writer prefers to take an independent line.

The total discharge of large rivers depends upon climate, precipitation and evaporation. The regularity of flow of rivers and streams throughout the year depends upon the storage capacity of the watershed, which feeds the stored water to the streams during the summer months through underground seepage and by springs. In winter or during tropical rainy seasons the rivers are fed directly by precipitation which reaches them chiefly as run-off. The influence of forests on seepage and run-off depends mainly on the extent to which the forests improve or otherwise the storage capacity of the watershed. This in turn depends on several factors, the principal of which are as follows:—

(1) Topography.
(2) Depth and physical nature of soil.
(3) Nature of underlying rock.
(4) Nature of precipitation.
(5) Nature of forest vegetation.

These factors will be considered one by one. Firstly and principally there is the factor of topography. Zon writes as follows: "All the water precipitated over an area covered with vegetation does not go to swell the underground drainage which feeds springs and the regular flow of streams. Some of it is dissipated before it has a chance to reach the lower strata. A part (i) is intercepted by the branches and leaves of vegetation, and is evaporated from them into the air; another part (e) is evaporated from the surface of the soil; a third part (r) runs off from the surface of the slopes into the valleys below;

and a fourth part (t) is absorbed by plants and used by them for the building up of tissue and transpiration. Finally, a surplus (s) which is left, over and above the amount absorbed by plants and evaporated by the soil, filters through into the ground and enriches the water which goes to supply the streams. Thus the water balance of any given area may be expressed in the form of an equation, in which $P = i + e + r + t + s$ and the amount of precipitation available for regular stream flow may then be expressed as $S = P - (i + e + r + t)$. Thus it is evident that, since the water available for streams is the amount which is left over and above that evaporated, transpired, and lost through surface run-off, the smaller the loss of atmospheric precipitation, the greater will be the amount of water that penetrates into the ground and becomes available for stream flow. Hence to determine the effect of forests upon stream flow, it is necessary first to determine whether a greater or less amount of precipitation is dissipated in a forested than in a treeless region. In a level country, where there is practically no surface run-off, the only sources of loss of water to the streams are interception by vegetation, evaporation from the soil, and transpiration. The water available for stream flow in a level country, therefore, may be represented by the equation $S = P - (i + e + t)$. In mountainous regions, on the other hand, surface run-off is one of the largest sources of loss to ground waters, and the hydro-physical influence of the forest in mountainous country is therefore essentially different from that in level country."

Zon has been quoted at length as he rightly draws proper attention to the question of topography. Now in Chapter II we have already quoted figures showing the amounts of water vapour given off by forests, and that the latter ordinarily contribute at least as much moisture to the air as other forms of vegetation, and in East Africa more than other forms of vegetation. This implies that forests on level ground act as soil desiccators. There is plenty of evidence available from all parts of the world to show that the forests of a level country reduce the subsoil water level, and it is on account of this reason that forests constitute such effective agents for draining swampy lands. But any statement that in level country forests act as soil desiccators must be qualified, as, if the underlying geological strata are not horizontal, the ground waters will be in motion. In other words, we would get underground run-off in place of the usual surface run-off.

We can sum up by stating that, in level country with horizontal geological strata, forests lower the subterranean water level, as they draw moisture from a greater depth than other forms of vegetation; they thus reduce the surplus of water available for stream flow.

In mountain forests, loss of precipitation through evaporation and transpiration is ordinarily less than on the plains, as the air temperature is lower. At the same time, precipitation is generally greater. This means that there is a bigger surplus (S) available for feeding streams. The important action which mountain forests have is to convert surface run-off into seepage. The forest floor, penetrated by a network of roots and covered by branches and stumps, offers many obstructions to the surface run-off, and so permits the water to sink into the ground. Percolation is made still easier by the presence of deep channels in the soil, left by the decay of large roots. Forests tend to increase the volume of soil and thus create greater reservoirs for

water. They do this in two ways: (1) From above, by the addition of leaves and twigs which, when decayed, become a constituent part of the soil; and (2) From below, by inducing disintegration and decomposition of the underlying rock. The forest, by constantly increasing the depth of the soil, lessens the likelihood of it being washed away. The addition of organic matter to the soil increases its water-holding capacity. The tree roots at the same time enter the narrow fissures of the rock, which they widen, thus producing many new openings into which the water may sink. A further important effect forests have is in checking the severity of the rainfall, as by their foliage and branches they break the force of the rain and prolong its duration. After a storm, water continues to drip from the leaves for one or two hours. It has thus a better chance of being absorbed by the soil. The reduction of surface run-off means both an increase of underground seepage and prevention of erosion—two important factors in the regulation of stream flow. It must be mentioned, however, that the ability of the forest to check surface run-off is greatest when the ground beneath is covered with an unbroken leaf litter. In the tropics the leaf litter is often destroyed by the action of termites as soon as formed, so that tropical mountain forests will not have the same effect in checking surface run-off as mountain forests in temperate climates. Forest fires have, of course, the same effect as termites in destroying surface litter.

We may sum up by saying that in hilly country forests are ordinarily conservers of water for stream flow. The steeper the slope and the heavier the precipitation the greater is their influence in this respect. By preventing erosion and checking surface run-off they increase underground seepage and so tend to maintain a steady flow of water in streams.

Secondly, we come to the factor of the depth and character of the soil. The depth of soil has a bearing upon the amount of water which it can retain, as, no matter what its character may be, a thin soil cannot retain much water. Forests, as we have already shown, tend to increase depth of soil, but we may get soils that are so thin that forest cover—which in itself would naturally be thin—can hardly improve their capacity for holding moisture. On the other hand, we can get soils which are of such a great depth that the influence of forests in increasing their depth and water capacity is negligible. Further, some soils are far more liable to erosion than others, and obviously the surface run-off from the latter will be less likely to be reduced by a forest cover. Again, the permeability or porosity of the soil has a great influence on the amount of surface run-off. On heavy clay or other impermeable soils the crowns of the trees, which break the violence of the rainfall, together with a surface mulch of the leaves (provided termites are not present) prevent the soil from becoming compact, and allow it to retain its granular structure, thus making it more permeable to water. Further, the roots of the trees will increase its permeability. On a soil very permeable to water, such as sand, the influence of the forest in decreasing surface run-off may be very insignificant, consisting chiefly in preventing the soil from being washed away.

We may sum up by saying that the moisture capacity of deep, porous soils, not liable to erosion. is less improved by a forest cover than that of shallow, non-permeable soils and soils liable to erosion.

Thirdly, there is the factor of the nature of the underlying rock. We have

already noted that in level country the inclination of the geological strata affects stream flow as, where horizontal, the water available for stream flow and springs is diminished by the presence of a forest cover. The nature of the rock itself affects stream flow. On fissured or permeable limestones 75 to 80 per cent of the rainfall is absorbed by the soil directly, an amount which could not be absorbed by any vegetable cover. If soils overlying such rocks support forest it is likely that the forest trees, by drawing upon the water stored in the rocks, will reduce the amount of water available for seepage. Such instances are rare, but in Kenya it is quite possible that the Shimba grit capping the Shimba Hills is a rock of this type, and as the Mombasa water supply is concerned it is a point of some importance and worth investigation.

We may sum up by saying that the greater the porosity of the underlying rock the less likely is a forest cover to exercise a beneficial influence on stream flow.

Fourthly, there is the factor of the nature of the precipitation. It is obvious that where the rainfall is normally continuous and light there is less need for the soil to possess a large moisture capacity than where the rainfall is heavy and irregular. Forests influence run-off most where the latter is the case, but whereas they can mitigate the severity of floods induced by very heavy rain they cannot prevent such floods.

Fifthly, the nature of the forest vegetation is an important factor. In the case of indigenous vegetation one generally finds that on wet soils the local flora tends to reduce the amount of moisture they contain; on dry soils it tends to increase such a moisture; while on intermediate soils its action in this respect is intermediate. It is otherwise with fast-growing exotics such as gums or wattles. Researches in South Africa have shown that black wattle, fast-growing gums and exotic pines exert a great desiccating influence on the soil. It is likely that they tend to reduce the water contents of the soil on all but the driest soils, and possibly even on the driest soils.

Consideration of the above factors shows that forests do not necessarily improve the water storage of a watershed or if they do improve it, they may, by their withdrawal of moisture supplies, decrease the total water available for seepage and springs. Obviously the problem is not one which admits of general conclusions applicable to all sets of conditions, but it is one which must be determined separately for particular localities. In the next chapter we propose to examine the factors of a few typical localities in Kenya to see how far forests are influencing seepage and run-off therein.

Before closing this chapter, reference should be made to one respect, unconnected with watersheds, in which forests can influence stream flow. The volume of water carried by a stream tends to decrease: (1) from seepage through underlying rocks; (2) from physical evaporation; and (3) from withdrawal of moisture by vegetation on its banks. The first source of loss is beyond control; the latter two losses admit of some control. We have already quoted in Chapter I the fact that evaporation from a free water surface is two and a half times greater outside than inside a forest. Further, if a water surface is sufficiently narrow to be shaded from the sun by surrounding forest trees, the losses from evaporation are likely to be still less compared with those from exposed surfaces. Further, in hot countries, there is likely to be a still greater difference between evaporation

inside and outside a forest. It may safely be assumed therefore that in East Africa evaporation from the water surface of small streams is at least three times as great outside forests as within forests. On the other hand, forest vegetation along a stream will tend to reduce the volume of water by transpiration more than would ordinary herbaceous vegetation (except payyrus). What difference in loss of water the two types of vegetation involve we do not actually know, but provided that the forest vegetation does not consist of exacting species, such as gums, it is practically a certainty that the loss must be less than the difference between evaporation inside and outside a forest. In the writer's opinion, forest vegetation along the banks of streams in Kenya is bound to help to conserve the volume of water in the streams, and wherever maintenance of water supply is required stream banks should be kept under forest or afforested.

Chapter VII.

Forests and Stream Flow—in Kenya.

The most important sources of water in Kenya are represented by Mounts Kenya and Elgon, the Aberdares, the Mau Escarpment extending northwards to Cherangani, the Kisii highlands, and the higher hill ranges which extend through Machakos and Kitui across the Tana River into Meru district. Far and away the most important soil is the ferruginous clay of volcanic origin which covers enormous areas on Mount Kenya, the Aberdares, and the Mau Escarpment. It is this soil which will form the subject of our first investigation into the influence of forests on water supply.

The red clay is confined to areas which are now or have been covered by forest. It varies from about two feet to about 40 feet in thickness. As a rule, it is deepest on ridges, thinning out as one descends into valley bottoms. In his "Report Relating to the Geology of the East Africa Protectorate" (1908), Muff lays great stress on the importance of preventing this soil from being eroded. He regarded it as certain to wash if cleared, on account of the steep slopes and the inabsorbent nature of the subsoil. He recommended that white settlers should retain the hill tops in forest and alternate strips of forest with tilled land on long slopes. On the subject of the value of forests in conserving the water supply of these soils, he wrote as follows: "The forests have a most important influence in regulating the volumes of the streams, apart from the debated question of their increasing the rainfall. They conserve the excessive rainfall of the wet season in the soil and subsoil, from which a portion seeps slowly into the stream-courses, whilst another part soaks down into the joints and fissures in the volcanic rocks, and issues as springs at a lower level. The forest thus decreases the immediate run-off of the rainy seasons, and increases the supply to the streams in the dry seasons. If the forests be destroyed the soil and subsoil will be eroded and most of the rainfall will run off at once into the streams. Thus the rivers will inevitably become torrents during the rains and dry up during the dry seasons. The springs will slowly diminish in volume, because the bare volcanic rocks cannot absorb as much water as when overlaid by water-holding soil and subsoil. The waterfalls of the Kikuyu country must be reckoned as a distinct asset to the power supply of the country. Their value depends in part on the permanent equality of volume and water, and thus on the presence of the forest."

With the above remarks the writer cannot agree. Of all soils which he has ever seen he considers that these red clays are about the least likely to benefit from

the retention of a forest cover. For one thing, they are not liable to serious erosion, except on very steep slopes. One may travel for miles over areas denuded of forest growth and see no eroded gullies except where on steep slopes cattle or human paths have hardened the surface and resulted in some wash below the paths. In stating that erosion is not serious it is not intended to imply that the soil does not lose in fertility. From the agricultural point of view, denudation does involve loss of the superficial organic layers of soil. But from the point of view of water supply the loss of superficial soil is not a factor of much account, owing to the ordinarily great depth of the soil. On such denuded soils the surface run-off is negligible. Although plastic, the soil is permeable. During prolonged heavy rain the water seeps slowly through the soil to underlying rock, along the edges of which it emerges as springs.

The value of forests on these red clays does not lie in any marked improvement of their water capacity but in the increased atmospheric precipitation which they engender. In the instability rains region, if our contentions are correct, forest will greatly increase the rainfall and hence the total supply of water. In the monsoon rains regions, forests on red soil, being all at high altitudes, will increase occult precipitation. On account of this influence of forests on precipitation and their beneficial action in reducing what erosion does occur, it could be argued that the red soils should all be kept under forest or afforested. Undoubtedly from the point of view of soil and water conservation, this would be an ideal, but who is going to benefit, except the Wandorobo, from the retention of the whole of the richest soils in Kenya under forest? Muff's proposal to keep the ridges under forest would involve redeeming from cultivation the most fertile tracts. The writer considers that the soundest policy is to keep the higher catchment areas and very steep slopes under forest and along the lower courses of streams to afforest or retain under forest their banks so as to reduce physical evaporation. Under no usual circumstances should exacting exotic species be planted along such lower reaches.

There are two soils which may be confused with the red clay soils. In the Trans Nzoia district there is a red soil which superficially looks like a red clay but which contains sand. This soil has not been studied, but it is probable that it would suffer from erosion, in which case the retention of forest cover is advisable on hilly ground, e.g. on the Cherangani Hills, where this soil occurs. Secondly, in the Igembe range in Meru district, and possibly elsewhere, there is a red loam, strewn with pumice stones, which is liable to very serious erosion when denuded of forest cover. This soil would undoubtedly benefit from the forest cover, but it is doubtful whether the local water supply would be influenced by a forest cover, as in such areas as are under forest the water sinks completely through the soil and emerges miles away on the plains below.

At very high altitudes the red clays are succeeded by acid peaty soils. The cause of the formation of these soils may be slow decomposition of organic matter as the colder and the wetter the climate, the lower the elevation at which they occur, e.g., on Mount Kenya, the moorland areas extend lower than on Mount Elgon. These moorland soils have not been studied, but the probability is that a forced cover would conserve water supplies. In view of the fact that they are at present unproductive, experiments in

afforestation would be well worth initiating. In any case, such bush as exists on the moorlands, and it is extensive and dense on Mount Elgon, should be conserved.

On badly drained land the red clays give place to black cotton soil, which covers fairly extensive areas in the Colony. As has already been mentioned, these soils are not naturally forest soils, but there are exotics which could be successfully planted upon them. The fact that drainage is bad means that the underlying rock is impervious. The effect of forests on such soils would probably be that of forests in level regions, i.e. the water contents of the soil would be reduced. Afforestation of such soils would therefore ordinarily result in improved drainage and not in improved water supply.

Among the most important soils on which forests can influence water supply are the sandy loams which occur on hills in Machakos, Kitui, Embu and Meru districts. In Machakos district the hills have been denuded of the forests which once covered them, with the result that serious erosion has occurred and streams have diminished or dried up. In the other districts denudation is now in progress, and it is only a matter of time before it is complete, unless measures are adopted to preserve and increase the forest cover. In Machakos district, afforestation operations are in progress on two or three hilltops, but unfortunately the area under afforestation is too small to exert much influence on water supply. At the very least, the top third of the hills ought to be afforested. Further, if water supply is to be regarded as one of the main aims of afforestation, the present policy of planting mainly gums should be altered, as the site factors cannot be classed amongst the very dry ones in which almost any species may be planted to preserve moisture. All the higher hills in the above districts are enveloped in mists while the south-east monsoon is blowing, so that the gain in water supply from schemes of judicious afforestation and forest conservation should be considerable.

The above survey of the influence of forests on water supply in Kenya is admittedly an incomplete one, but the writer has not sufficient personal experience to be able to deal with all the conditions which occur, and, in any case, a detailed examination of all such conditions would be beyond the scope of this memoir. The main point to be stressed is that forests do not invariably increase stream flow, and, where water supply is a consideration, choice of species in all afforestation operations should be given careful attention. Apart from the above, the writer would like to stress on riparian owners the advantages of maintaining or creating forest cover along stream banks.

Chapter VIII.

Forests and Wind: The Value of Windbreaks.

Is Africa drying up? There is a great deal of evidence, hydrological, geological and botanical, to show that parts of Africa are undergoing progressive desiccation. This is particularly the case in the West African colonies, where dry, desert conditions are advancing from the north. There is some evidence to show that parts of Kenya and Uganda (e.g. Karamoja; Lake Rudolf) are in course of drying up. Is such desiccation likely to progress further in East Africa? Before we answer this question we must define what is meant by the term "desiccation". It may cover several climatic features, such as: (1) reduction in rainfall; (2) reduction in stream flow; (3) reduction in subsoil water level; and (4) excessive evaporation due to a reduction in the

relative humidity of the air. A diminished rainfall may be due to general climatic variations over which one has no control, but it may be induced by forest destruction, as has been pointed out in previous chapters. Reduction in stream flow and subsoil water may be induced directly by forest destruction or it may follow indirectly as a result of reduced rainfall. We have already drawn attention to how forests can influence these factors. We have yet to draw attention to the vast economic influence which forests and windbreaks can exercise on evaporation and the humidity of the air. The purpose of this chapter is to emphasize the importance of the influence which forests and windbreaks can exercise on atmospheric humidity and crop production.

The evaporation of water and the transpiration of moisture from plants is accelerated by three conditions: heat, dryness, and rapid air circulation. Anything which reduces the movement of the air reduces the rate of evaporation and transpiration. It has been pointed out in Chapter I that the relative humidity of the air is greater inside than outside forests. This fact is due partly to the greater amount of moisture given off by forests and partly to the fact that forests check wind velocity and air circulation. The latter object can be secured not only by extensive areas of forest but by narrow windbreaks. In Kenya, except for most of the Northern Frontier Province, where the south-east wind has lost its ocean moisture and become a dry wind, the dry wind to be feared is that which blows from east to north-east. All features which tend to check the velocity of this wind or increase its moisture contents are of value. Hill ranges play their part, but so do forests, whether they consist of thorn-bush or dense high forest. If the forests which help to protect most of the fertile tracts of Kenya from the desiccating influence of the north-east winds are destroyed, the probability is that, owing to increased evaporation, natural vegetation will become of a drier type and agricultural crop production will be adversely affected. We cannot definitely answer the question whether desiccation will progress in Kenya, but by forest preservation we are putting up the best defence we can, and by afforestation operations we can take what is likely to prove an efficient offensive.

Some of the important hill ranges which help to protect Kenya from the dessicating north-east wind are already gazetted forest areas, but there are other protective ranges on which forests should be preserved or created. This is a matter for State action. It is not sufficient, however, to offer one or two main barriers of defence, as, after surmounting the main barriers, the winds will again tend to gain in velocity and dryness if they are left free to sweep over treeless plains. Behind the main barriers one must have subsidiary lines or defence or attack, and manifestly these must be established by private or communal enterprise. A striking example of what can be achieved by co-operative action is to be found in the Middle Western States of America, where the early settlers went in for extensive windbreak planting to build up a natural barrier against the winds which then swept unimpeded across the plains, doing immense damage to their crops and intensifying the effects of both hot and cold weather upon their stock.* To-day these

*Similar action is now being taken on the Canadian prairies. It was reported in March, 1929, "that there are now about 55,000 flourishing plantations scattered over the Canadian prairies where in former times one could travel for miles without seeing a tree. Besides affording shelter for homesteads and crops and preventing soil drifting, these plantations have made it possible to establish orchards, vegetable gardens, and planting of bush fruits, such as raspberries and currants, all of which were practically unknown on the prairies a few years ago".

States are no longer the prey of winds. Cannot the same action be taken in Kenya? The writer is convinced that by co-operative tree-planting action, the climate of Kenya can be greatly ameliorated, with far-reaching results on crop and stock production.

Before establishing windbreaks, the farmer will want to know what the effects of such windbreaks will be on crop production. A publication of the United States Department of Agriculture by C. G. Bates, entitled *Windbreaks: Their Influence and Value* (1911), gives a large number of useful data on the subject. A summary of the influences of windbreaks upon the physical factors which affect the growth of plants, which is taken from this work, shows that:—

"(1) *The Zone of Competition.*—In a narrow zone or belt adjacent to the trees there is competition, which results unfavourably to the annual crops by reason of:—

(*a*) Loss of Sunlight.—This amounts to from 50 to 125 per cent of the light which might fall on an area as wide as the height of the trees. This loss is greatest in the case of north—south windbreaks. On such shaded areas the light may be sufficient for vegetative growth but will be insufficient for seed production. They should be utilized for forage crops or for slow-growing trees which tolerate shade.

(*b*) Loss of Moisture.—A zone varying in width from one to five times the height of the trees is affected according to the species and locality factors. Extensive tree root systems are encouraged by lack of rainfall, light infertile soils, or impermeable subsoils and a heavy soil cover of grass. The width of the affected strip can be greatly reduced by cultivation. In years of drought the loss of moisture in the affected zone may result in a complete loss of annual crops.

(*c*) Temporary Reduction of Soil Fertility.—This accompanies and is due to the loss of moisture in the root zone.

(2) *The Zone of Windbreak Protection.*—In the wider zone of windbreak influence the protection afforded results in a marked benefit to crops, because of the creation on a large scale of conditions similar to those which obtain in a hothouse. These conditions, all of which result from the ability of windbreaks to check the circulation of air currents, are as follows:—

(*a*) Less Wind Movement.—Windbreaks exert a calming influence on wind velocity for distances up to twenty times their height. As a result there is less lodging of grain and movement of loose soils.

(*b*) Less Evaporation.—This results in the ultimate conservation of the moisture in the soil, as the stagnation of the air permits the formation of a more or less complete blanket of humid air, or, in other words, the rapid dissemination of moisture is stopped. The loss of moisture by evaporation is the crucial feature of the effect of winds upon crops. Protection from evaporation is appreciable for a distance equal to five times the height in a windward direction and up to twenty times the height leeward. An efficient windbreak will reduce evaporation within this zone by at least 33 per cent. In a rainfall of 36 inches, 12 inches will thus be saved!

(*c*) Greater Heat during the Hours of Sunshine and Less Extreme Cold at Night.—This influence on temperature, and consequently on crop production, may be more than sufficient to offset damage due to shading (except in the case of crops like wheat, which require little heat).

The absolute value of any of these influences will increase with the degree of efficiency of the windbreak, and their total amount on any side of the windbreak will depend upon the direction, velocity, and desiccating power of the prevailing winds."

The above summary of the influences of windbreaks may leave a confused impression that the good they do is counterbalanced by evil. This is not the case. European agricultural economists recommend that 20 per cent of a farm should be under forest where protection from two winds is required. This recommendation is accepted by Bates for the U.S.A. in the above-mentioned work. In Kenya there is generally only one wind to be

guarded against, and this means that about 10 per cent of a farm should be under forest. Apart from the value of the timber and firewood in a windbreak, the protection afforded by an efficient windbreak amounts, according to American experience, to the yield of a strip from two to three times as wide as the height of the trees. The judicious planting of windbreaks therefore will not involve sacrifice of farm land, but, on the contrary, it should lead to increased total productivity.

A few notes on windbreaks should prove interesting. To be efficient, windbreaks must not permit wind to pass through below the crowns of the trees. If they do so, they will do more harm than good, as they will cause higher and drier strata of air to be deflected downwards. Windbreaks can be of two main types, i.e. single row or multiple row. Single row windbreaks or hedges exercise a greater beneficial influence in comparison to the space they occupy than do multiple row windbreaks, but they will generally require periodic cutting back. They cannot produce as much or as useful timber as multiple row windbreaks. As a general rule, the latter are likely to prove most useful to the farmer, while single row hedges will be more popular for owners of gardens or smallholdings. Where it is not the intention to grow timber for profit, the width of a multiple row windbreak (from outside trunk to outside trunk) should not exceed twice the expected height of the trees at maturity. A good general rule would be to make the width equal to one-and-a-half times the height and to space the windbreaks fifteen times the height apart. This gives us ten per cent under forest. For instance, windbreaks 60 feet high should be 90 feet wide and 900 feet apart. Economy, where necessary, should be effected by reducing the width of the windbreak.

The choice of species is an important consideration. It is beyond the scope of this publication to recommend specific types of windbreak for specific localities. The Forest Department will always be willing to give individual advice on this subject, but it is likely to take many years of practical experience before the best types for all localities will be ascertained. A good general rule would be to select a fast-growing species for the body of the belt and later underplant with a slow-growing dense foliaged tree, or plant the latter along the sides of the main body. Gums are at present very popular in Kenya. They have been successfully used in California for the protection of citrus orchards, but they have their drawbacks. They cannot be underplanted, and as they only form a dense windbreak for a number of years they have to be periodically cut down. The latter is not a drawback if the belt is sufficiently wide to permit of trees being cut down in rotation without impairing the efficiency of the windbreak. Again, gums have extensive horizontal roots which sap moisture from the soil. This is not much of a disadvantage in the case of forage crops, but it is decidedly so in the case of seed crops. Intensive cultivation of the soil and trenching will mitigate loss of moisture from sapping, but such operations involve expense. On the whole, in the case of seed or fruit crops, it is probably better to avoid gums and to select instead such species as the Cypresses, the Casuarinas, the pepper tree, etc., which are less exacting than gums.

In conclusion, the writer would again like to stress the great benefits which are likely to accrue from co-operative schemes of windbreak planting. Moisture of soil and air is a national asset. Why then

permit excessive evaporation and the blowing out of the country of moisture which can ill be spared and should be conserved? Further, in the regions of instability rain, any factors which reduce wind and conserve moisture are likely to induce greater rainfall. One progressive farmers' association has recently advocated co-operative action with regard to tree planting. May all others soon follow suit. If this pamphlet succeeds in arousing further active interest in this subject it will have achieved an object which, in the writer's opinion, will exercise far-reaching consequences on the climate and productivity of Kenya.

Chapter IX.

Conclusion.

In preceding chapters the extent of the influence exerted by forests on climate has been dealt with in an impartial manner. If forests are not the panacea for deficiencies of rainfall and water supply which some people would like to believe, they have at any rate got an indispensable role to play in the life-history and development of Kenya Colony. Further, the State cannot by itself perform miracles of climatic reformation by afforestation operations on a gigantic scale. Individual and communal action must supplement the State's efforts by the establishment of windbreaks and the maintenance or creation of forest cover along stream banks. Granted that such individual and communal action is a necessity, the question may well be asked whether the State itself, within the limitations which must govern its actions, is doing all it can to preserve and increase forest areas of climatic importance. The reply is that much has been done, but that much still remains to be done. Unfortunately, many of the areas of climatic importance lie within tribal boundaries, and political issues complicate the subject of the assumption of State control over such areas. This is not the place to raise political controversies, but the writer would like to emphasize the fact that climate recognizes no tribal or individual farm boundaries. Some forests may be of very local climatic influence: the majority exercise a regional influence on climate. These latter must be recognized as a national asset, and their control, no less than that of areas which in the general interests of the Colony should be afforested, ought to be national. In most European States the free management of private forests is limited by State control. Similar control is required in Kenya, and the most pressing forest problem requiring solution in Kenya to-day is the subject of State control over or management of such forest areas as lie within tribal or individual boundaries. Let us hope that a satisfactory statesmanlike solution will be reached, and that in the future the general welfare of the people of the Colony of Kenya will prevail.

Pigs for Bacon Production

A Comparative Trial with Large White and Edelschwein Pigs

By M. H. FRENCH *and* H. E. EMSON, *Veterinary Department, Tanganyika.*

With the revival of interest in the pig industry in the Southern Highlands of this Territory many problems have arisen in connection with the breeding and management of pigs. The present market can accommodate both bacon and sausages, and these articles are now being prepared. Sausages can be made from pigs of almost any breed and conformation, whilst bacon production requires a standardized type of pig. The market for pig products therefore allows all the pigs of suitable age and confirmation to be converted into bacon, whilst all unsuitable pigs can be chopped into sausages.

The farmers of the Iringa District have individual prejudices and likings for particular breeds and crosses of pigs. Further, each farmer is trying to feed his animals as economically as possible, making the utmost use of home-grown feeding stuffs. The result is that the pigs are not being marketed at a standard size, because the non-standard animals can be turned into sausage meat. Also, at the present time, there is little or no difference in the prices paid for the good type of bacon pig and for the animal destined for sausage production.

The market for bacon is capable of developing to a very much greater extent than the sausage market. It is therefore necessary that as much information as possible should be collected regarding the feeding and breeding of the *bacon* type of pig. A beginning has been made with the study of both the breeding and feeding problems during this last year. This article, however, is concerned only with the comparison of different breeds for bacon production.

In the Iringa Province, both British and German farmers are keeping pigs, so that it is not surprising to find a very mixed pig population in the district. The Germans prefer a much fatter carcass than is considered to be ideal by the British population. This fact is reflected in the types of pig kept by the farmers: the British farmers prefer the Large White or its crosses, whilst the German farmers are breeding the Edelschwein and its crosses.

The object of the pig farmer is to get a certain standard type of pig. The earlier maturing a pig the quicker it reaches the desired conformation, but all the quick-growing pig breeds reach the ideal distribution of meat, fat and bone at a weight which gives too small a carcass to meet the requirements of the bacon market. If such breeds are kept on to bacon weight (200 lb. live weight), they yield carcasses which are too fat.

Late maturing pigs yield the optimum distribution of meat, fat and bone in the carcass at a much heavier weight. The object of any study on bacon production is therefore to obtain the correct proportional carcass distribution at a weight which will allow the various bacon cuts to be marketed at those weights demanded by the consumers.

Some breeds of pig are more suited for bacon than for pork production, but the strain of pig is probably of more importance than the breed. Further, it is possible to affect very considerably the conformation of a pig by its plane of nutrition. The desired conformation and distribution of meat, fat and bone can be reached by the heavy feeding of a slow-maturing

breed or by keeping an earlier maturing breed on a reduced nutritional level.

This particular study was designed to compare the local strains of Large White and Edelschwein pigs for bacon production. In this preliminary trial, three pens of pigs were arranged, respectively consisting of pure-bred Large White pigs, pure-bred Edelschwein pigs, and the progeny of a Large White sow crossed with an Edelschwein boar.

The pigs were fed what is considered to be the most economical ration available locally, though it is by no means the best ration that could be designed. As the same ration was used for all the pigs, and as the pigs were under the same management conditions, any differences in the carcasses can be attributed to breed differences.

The ration fed to the three groups of pigs was composed of the following:—

60 per cent Maize meal (costing 6 cents per kilo.).

30 per cent Barley meal (costing 14 cents per kilo.).

10 per cent Meat meal (costing 48 cents per kilo.).

One kilo of this mixture therefore works out at a cost of 12.6 cents. In addition, the pigs received daily 1 oz. of a salt (one part) and bone meal (two parts) mixture, the cost of which worked out at 83.32 cents per pig for the 101 feeding days of the experiment.

The pigs were not of the same age at the commencement of the fattening period, because it was only possible to get pure-bred Edelschwein pigs which were about four weeks older than the Large White and cross-bred pigs. Each group of pigs contained two castrated males and two female animals, and each group was composed of pigs from the same litter. The animals had all been kept under the experimental conditions for a fortnight before the fattening trial began. The details of the food consumption are shown in Table I, and each pen received the same ration daily.

TABLE 1

AVERAGE DAILY FOOD CONSUMPTION

Interval	Average Daily Consumption
15 days	1·50 kilo.
15 ,,	1·75 ,,
15 ,,	2·00 ,,
17 ,,	2·25 ,,
39 ,,	2·50 ,,

The cost of feeding was the same for each group of pigs, and worked out at an average of Sh. 27/23 for each individual pig. The results of this feeding trial are summarized in Table II, but it is necessary to mention that in assessing the profit to be made on each pig the wages of the boy, the bonus paid to the boy for each live pig delivered to the factory, the initial purchasing value (40 cents per lb.), the cost of feeding and the cost of transport, have been deducted from the price paid by the bacon factory (38 cents per lb. live weight). No attempt has been made to cover the depreciation of buildings and equipment, and to allow for the risk of death, etc.

The results of this feeding trial indicate that there is no significant difference in the rates of fattening between the Large White, the Edelschwein or the cross between these two breeds. With the present rates of fattening and utilization of the food fed, the Edelschwein pigs made nearly Sh. 2 less profit than the Large White or the cross-bred pigs. The table shows quite plainly that, with the existing prices in the Iringa District, a satisfactory profit can be made by those farmers who fatten pigs for bacon production.

TABLE 2

SUMMARY OF FEEDING TRIAL

	Pen 1	Pen 2	Pen 3
	Large White	Large White + Edelschwein	Edelschwein
	lb.	*lb.*	*lb.*
Average initial weight ..	63·25	47·5	65·1
Average final weight ..	214·00	197·0	211·25
Live weight increase in 101 days	150·75	149·5	146·15
Average daily live weight increase ..	1·49	1·48	1·45
Amount of food consumed to produce 1 lb. increase ..	3·13	3·16	3·23
Cost of food fed	Sh. 27/23	Sh. 27/23	Sh. 27/23
Cost of producing 1 lb. live weight increase ..	18·1 cts.	18·2 cts.	18·6 cts.
Average profit per pig during fattening period ..	Sh. 25/22	Sh. 25/07	Sh. 23/43

Carcass Trials.—Although there is little difference between the Large White and the Edelschwein pigs in their rates of fattening, there is a big difference in carcass quality.

The body conformation of the two breeds is markedly different, whilst the cross-bred pigs have a conformation intermediate between those of the two parent breeds. The Edelschwein has coarser skin and hair than the Large White. At bacon weight (200 lb. live weight), the Edelschwein is shorter, wider and much fatter than the British breed, and also possesses very heavy jowls and shoulders. The German breed also has somewhat coarser bones, so that its short stumpy legs and heavy body make it appear much shorter than it is in reality.

After slaughter, linear and avoirdupois measurements were made on each carcass and the results of each group are summarized in Table III.

TABLE 3

AVERAGE WEIGHT AND LINEAR MEASUREMENTS OF CARCASS

	Large White	Large White × Edelschwein	Edelschwein
Live weight (lb.).. ..	214·0	197·0	211·2
Carcass weight (lb.) ..	170·4	144·9	166·9
Carcass percentage of live weight	79·6%	73·6%	79·0%
Secondary offals (lb.) ..	42·5	36·0	38·8
Secondary offal percentage of carcass weight ..	24·9	28·4	23·2
Weight of hams (lb.) ..	31·1	27·5	30·2
Hams as percentage of carcass weight.. ..	18·3%	19·0%	18·1%
Weight of shoulders (lb.)	41·3	31·9	35·2
Shoulders as percentage of carcass weight.. ..	24·2	22·0	21·1
Weight of sides (lb.) ..	55·4	49·5	62·7
Sides as percentage of carcass weight	32·5%	34·2%	37·6%
Length of side (inches) ..	30·5	28·7	28·6
Thickest layer of back fat (cm.)	4·4	4·7	5·7
Thinnest layer of back fat (cm.)	2·0	2·7	4·0
Thickness of streak (inches)	1·26	1·04	1·27
Shoulder muscle thickness (cm.)	9·6	8·5	9·3
Shoulder fat thickness (cm.)	3·6	4·3	5·3
Loin muscle length (cm.)	9·4	8·0	7·8
Loin muscle depth (cm.)	4·4	4·6	5·2
Loin fat thickness (cm.)..	2·0	2·6	3·8

The figures in this table illustrate very clearly the extent to which the Edelschwein breed of pigs forms a much thicker layer of fat around its body. The great thickness of back fat and the thick streak would cause such pigs to be graded low in a facon factory producing bacon for the British palate.

This very fat nature of the Edelschwein carcass causes the percentage of secondary offals to be low, and the sides to form a higher proportion of the total carcass weight than in the Large White breed. The muscular development was greater in the Large White pigs. This may have been due to this litter of pigs receiving the better feeding at the time of weaning, because the nutritional plane

at the time of weaning affects considerably the size of the muscles, and particularly the size of the loin muscle (the "eye" of the loin joint).

In the growing animal the phase of maximum rate of growth occurs first of all in the skeletal structures, then in the muscular tissues, and finally in the fat deposits. The early maturing breeds pass through the first phases more quickly than slow growing breeds, and so start to deposit fat at an earlier age. This is what has happened in the case of the two breeds studied above. The Edelschwein started to convert its food into fat at an earlier age (and therefore similar live weight) than did the Large White. The formation of fatty tissues requires a larger amount of food than does the formation of a smaller weight of mixed muscular and fatty tissues, and this explains why the Edelschwein has a lower rate of food utilization than the Large White breed.

From the carcasses examined at the bacon factory it was observed that to get the same proportional distribution of meat, bone and fat in the carcass of the Edelschwein as was possessed by the Large White pigs, killed at 200 lb. live weight, the Edelschwein needed to be killed at about 140 lb. live weight.

It is therefore clear that the Edelschwein pigs in the Iringa District are unsuited for the production of bacon for British consumers. Though we are not so familiar with the German bacon tastes, we gather that even for this purpose the Edelschwein carcasses were too fat. It would probably have been better, assuming that the German settlers prefer a German breed to a British breed of pigs, if they had introduced the Improved Land Race breed rather than the Edelschwein.

Whilst admitting that the market demands for pig meat are of a very mixed type, and that preferences for different breeds of pigs are bound to occur, we maintain that the industry would develop much quicker were one particular type of pig encouraged by the factory. The Large White pig can satisfy almost any market requirements. By varying the plane of nutrition, the Large White can be fattened for the pork market, the bacon market or for the fat bacon market (when at 250 lb. live weight). Since standardization of the quality of the product goes a long way towards establishing an industry, the adoption of one general utility breed of pig, such as the Large White, would do much towards the evolution of such a uniform product.

Conclusions.—There is no significant difference between the rates of fattening for the Large White, Edelschwein, or their cross-bred pigs.

The Edelschwein carcasses are much fatter and shorter at a given weight than are those of the Large White breed.

The Edelschwein is too fat at 200 lb. live weight to meet the requirements of the British palate for bacon production. This breed reaches the desired conformation and correct body proportions at a much lower weight (120-140 lb. live weight).

The cross-bred pigs from the mating of a Large White sow and an Edelschwein boar take an intermediate position between the two parent breeds for bacon production.

Acknowledgments.—It is with great pleasure that we acknowledge our indebtedness to Mr. A. Hauter, of Dabaga, who kindly allowed this experiment to be carried out on his farm, and who supervised the feeding of the pigs. We are also grateful for the help and facilities given by the Mtitu Bacon Factory, on whose premises the carcass tests were carried out.

Comparative Values of Some East African Foods for Bacon Production

By M. H. FRENCH *and* H. E. EMSON, *Department of Veterinary Science and Animal Husbandry, Tanganyika Territory.*

Farmers in East Africa must of necessity utilize as many home-grown feeding stuffs as possible in the dietary of their live stock. The purchase from outside sources of highly nitrogenous concentrates and of cereal grains is, in the majority of cases, attended by very high transport charges. It was therefore considered advisable to test out mixtures of locally grown foodstuffs for the purpose of fattening pigs for bacon production.

This particular series of three rations was undertaken for the benefit of the Iringa pig farmers, but the results are of sufficient general interest to warrant their wider publication. The trials were carried out at Dabaga on pigs supplied locally, whilst the feeding stuffs used in the three rations were all easily procurable in the district. With the exception of meat meal, all the other feeding stuffs were grown locally.

The pigs used for this study were from three litters. Three groups of six pigs each were then arranged by taking two pigs from each litter, and drafting the animals in such a way that the different groups were as similar as possible in regard to live weight, size, sex and general appearance. The litters were of different ages, so that each pen contained two large, two medium, and two small pigs. Whilst it is realized that it would have been better had all the pigs in each group been of the same size, this was not possible to arrange. From the rates of live weight increase it appears probable that the larger pigs obtained the larger proportion of the food fed, and the differences in weight observed at the beginning of the experiment were accentuated by the end of the fattening period. This condition holds equally well for all three groups, so that the final results can be regarded as comparable.

The pigs were typical of many in the district, and were the progeny of sows of mixed breeding, crossed with a pure-bred Edelschwein boar. Edelschwein, Large White, Middle White and possibly Large Black pigs were represented in the ancestry of the three sows from which the litters were taken. The development of the pig industry in Iringa is still in its early days, and the bacon factory has not yet adopted a standard type of pig because they have a large sausage trade which at the moment absorbs the non-bacon types. The result is that each farmer is rearing whatever breed he likes, whilst other farmers are just rearing pigs without any reference to breed. When one adds to this uncontrolled and unstandardized pig breeding the fact that both British and German farmers are breeding pigs, and that there is a national difference in what is considered the ideal type of pig, it is easy to visualize the chaotic state of the Iringa pig industry.

The rations which it was decided to test out were mixtures composed of maize, barley, wheat, field peas, pigeon peas, wheat bran, and meat meal. The farmers of the Southern Highlands grow maize in considerable quantities, and the natives plant large areas with this grain. Wheat is being grown fairly widely by the European settlers, and all the best quality grain is sold to flour mills. Only the poorer quality wheat and any surplus

above that required by the mill is used for feeding purposes. Barley is grown by most pig-farmers, but the grain is fibrous, small, and not well filled. Field peas are grown in certain areas for the leguminous grain and for enriching the soil fertility. Pigeon peas are widely used as a cover and shade crop for young coffee trees and plenty of this grain can be obtained.

The object of this experiment is to determine to what extent these farm-grown foods can be used alone, or with the minimum amount of meat meal purchased from outside the farm. It was therefore decided to feed one group of pigs without meat meal, the nitrogenous concentrate being supplied in the form of peas. Another group was given a small amount of meat meal with maize as the basal part of the ration. The third ration was designed to utilize wheat instead of maize as the basis of the diet. The details of the compositions of the three rations are given in Table I, together with the cost per kilo of each food.

TABLE I

COMPOSITION OF RATIONS FED, TOGETHER WITH THEIR COSTS

	Maize	Barley	Wheat	Wheat Bran	Field Peas	Pigeon Peas	Meat Meal	Cost per Kilo of Mixed Rations
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Cost per kilo of each foodstuff .	6	14	10	·2	11	12	48	—
	%	%	%	%	%	%	%	
Pen A ..	50	—	—	10	40	—	—	7·6
Pen B ..	55	20	—	—	20	—	5	10·7
Pen C ..	—	20	45	—	—	30	5	13·3

The three groups were started together on their fattening periods on 9-11-35, and a steady rate of increase in weight was obtained. However, it was soon very apparent that Groups B and C were doing much better than Group A. The pigs in pen A did not exhibit the same avidity for their food as did the pigs in the other two groups, and the average daily food consumption in pen A became lower than in the other two pens. This fact serves to illustrate still further the general observation that rations containing an animal protein are more appetizing than similarly well-balanced rations composed entirely of vegetable material.

The average daily food consumptions of the pigs in each pen are given in Table II.

TABLE II

AVERAGE DAILY FOOD CONSUMPTION OF EACH PIG

INTERVAL	Group A	Group B	Group C
	Kilo	*Kilo*	*Kilo*
9–11–35—23–11–35	1·50	1·50	1·50
24–11–35—30–11–35	1·75	1·75	1·75
1–12–35— 9–12–35	1·50	1·75	1·75
10–12–35—23–12–35	1·50	2·00	2·00
24–12–35— 9–1–36	1·75	2·25	2·25
10–1–36— 17–2–36	2·00	2·50	2·50

The cost of feeding each pig in the three groups for the 101 days of the experiment can easily be calculated. In addition to the rations shown in Table I, each pig received daily one ounce of a bone meal and salt mixture. This mixture was composed of 4 parts of bone meal and 1 part of salt. The cost of feeding one ounce daily to each pig for 101 days was 83 cents. It is seen therefore that the feeding of each pig cost respectively for—

Pen A ... ... Sh. 14/28
Pen B ... ... Sh. 23/68
Pen C ... ... Sh. 29/36

Thus the farmer who feeds no meat meal to his pigs reduces very considerably the daily cost of feeding his pigs,

but at the same time the appetite and consequently the rate of fattening are also reduced. The extent to which the omission of meat meal from the ration affected the rates of growth in the present trial is seen in Table III.

TABLE III

AVERAGE LIVE WEIGHT CHANGES

	Average Initial Weight	Average Final Weight	Average Increase	Average Daily Increase
	lb.	*lb.*	*lb.*	*lb.*
Pen A ..	51·7	150·3	98·6	0·98
Pen B ..	51·8	172·3	120·5	1·19
Pen C ..	52·8	171·0	118·2	1·16

These figures indicate that a ration in which the basal cereal grain is changed from maize to wheat allows the same rate of fattening to proceed as when the more usual maize basis is employed. Further, the omission of the 5 per cent meat meal from the maize ration and its replacement by peas reduces the rate of growth by one-sixth.

It thus becomes a matter of simple economics whether or not a farmer will utilize only home-grown foods for the rearing of bacon pigs. By leaving out the costly animal protein he gets a cheaper ration but slower growth. The relative prices of the various feeding stuffs vary according to locality, and one cannot make any hard and fast statement. Each farmer must decide for himself what policy he should adopt on this question.

In the case of the Dabaga District, with the prices of the feeding stuffs as stated in Table I, the pigs of pen A, fed no meat meal, showed a slightly greater net profit than did the pigs of pen B, receiving meat meal. The pigs of pen A, however, were the smaller, and had they been kept on another three to four weeks to enable them to reach the same live weight as the pigs in pen B, there would have been a much wider margin of profit in their favour.

In assessing the profits for each pig the following factors have been accounted: The wages of the boy who looked after the pigs have been equally divided amongst all the pigs. For each live pig sold to the factory the boy also received a bonus of 50 cents. The transport charges have been equally divided amongst the pigs. The value of the pigs at the beginning of the trial is reckoned at 40 cents per lb. live weight, whilst the selling value at the factory is 38 cents per lb. live weight.

On the basis of these figures and the food costs already given in Table I, but making no allowance for depreciation and risk, the profits have been calculated for each group. The details of the fattening trials are summarized in Table IV.

TABLE IV

SUMMARY OF FATTENING TRIALS

	PEN A	PEN B	PEN C
	Fed Maize, Bran and Peas	Fed Maize, Barley, Peas and Meat Meal	Fed Wheat, Barley, Peas and Meat Meal
Average initial weight ..	51·7 lb.	51·8 lb.	52·8 lb.
Average final weight ..	150·3 lb.	172·3 lb.	171·0 lb.
Average live weight increase in 101 days ..	98·6 lb.	120·5 lb.	118·2 lb.
Average daily live weight increase	0·98 lb.	1·19 lb.	1·16 lb.
Cost of food fed to each pig	Sh. 14/28	Sh. 23/68	Sh. 29/36
Average food consumption per lb. live weight increase	3·75 lb.	3·91 lb.	3·98 lb.
Cost of food fed to produce 1 lb. live weight increase	14·48 cts.	19·65 cts.	28·84 cts.
Profit over fattening period for each pig ..	Sh. 18/48	Sh. 17/47	Sh. 10/93

The figures show that the replacement of the basal maize portion of the diet by wheat did not alter significantly the rate of live weight increase. The extra cost

of the wheat ration and the slightly poorer rate of utilization reduce the profits on the wheat-fed pigs by approximately one-third. Pen A, which received no meat meal, showed the smallest rate of increase, but made better use of their food than did the other two groups. It is easy to see from these figures how the profit from this group of pigs would be much higher had the pigs been kept on till they reached the same live weight as the pigs of groups B and C.

Referring to the food consumption per lb. of live weight increase, the lower value for the non-meat-meal ration may be due to the fact that the pigs in this group were smaller, and so stored a smaller percentage of fat in each lb. of live weight increase than did the heavier pigs of the other two groups. The deposition of body fat requires the consumption of more food than does the formation of an equal weight of other tissues.

The most striking thing about the table is the high food consumption per lb. of live weight increases. This is possibly explained by (1) the poor type of pig used in these trials, (2) the struggling for trough room, because the feeding troughs were on the small side, and (3) infection with roundworms. In a previous study with a better type of pig, but under the same management and cramped feeding conditions, a lower rate of food consumption was obtained.

The experiment indicates that a satisfactory profit can be made by fattening pigs with farm-grown feeding stuffs, with or without the help of a protein concentrate of animal origin. It also appears that wheat is an expensive feed for pigs, and so only the wheat which cannot be sold should be utilized for this purpose.

Carcass Tests.

All the pigs in this trial were destined for bacon production, and the carcasses were all examined and measured after slaughter. Linear carcass measurements were made in addition to the determination of the weights of the various parts and joints. The results of these measurements are summarized in Table V.

TABLE V

Average Carcass Measurements

	Pen A	Pen B	Pen C
	Fed Maize, Bran and Peas	Fed Maize, Barley, Peas and Meat Meal	Fed Wheat, Barley, Peas and Meat Meal
Live weight (lb.) ..	150·3	172·3	171·0
Carcass weight (lb.) ..	114·4	137·3	135·5
Carcass as percentage of live weight	76·1%	79·7%	79·2%
Secondary offals (lb.) ..	29·9	33·6	32·4
Secondary offals as percentage of carcass ..	26·1%	24·4%	23·9%
Weight of hams (lb.) ..	22·0	24·9	25·3
Hams as percentage of carcass	19·2%	18·1%	18·7%
Weight of shoulders (lb.)	24·4	29·5	29·5
Shoulders as percentage of carcass	21·3%	21·5%	21·8%
Weight of sides (lb.) ..	38·1	49·3	48·2
Sides as percentage of carcass	33·3%	35·9%	35·6%
Length (inches)	26·4	27·8	27·9
Thickest layer of back fat (cm.)	4·5	4·8	4·6
Thinnest layer of back fat (cm.)	2·7	3·3	2·9
Thickness of streak (inch.)	0·85	1·11	1·00
Shoulder muscle thickness (cm.)	7·0	7·8	7·5
Shoulder fat thickness (cm.)	4·1	4·7	4·7
Loin muscle length (cm.)	7·6	7·5	7·6
Loin muscle thickness (cm.)	4·0	4·2	4·9
Loin fat thickness (cm.)	2·4	3·2	2·7

The pigs at the time of slaughter were on the average below the ideal bacon weight (200 lb. live weight), but this was because each pen contained some large pigs and some small pigs, and the larger pigs in each group were ready for slaughter.

The animals were short and too fat for the production of ideal bacon for the

British palate. The animals had coarse skin and hair, with heavy jowls and shoulders.

The carcasses of the large animals would all have been graded low because of over-fatness. The smaller animals (120 to 140 lb. live weight) possessed the required distribution of meat, fat and bone.

These results indicate that the type of pig used in these trials is not suited for the production of good quality bacon. Also the examination of the nature of the carcass fats indicated that the ration containing no foodstuff of animal origin produced a softer and more greasy fat than the rations fed to groups B and C.

SUMMARY.

Farm-grown feeding stuffs are quite suitable for bacon production purposes, and the profits from fattening pigs can be quite satisfactory, whether the farm foodstuffs are fed with or without protein of animal origin.

The omission of a foodstuff of animal origin detracts from the palatability of the ration and leads to a lowered rate of food consumption and a reduced rate of fattening.

Wheat can replace maize as the basis of the pig ration without altering the rate of fattening. The quality of the carcass from wheat-fed pigs is similar to that of the maize-fed animals. The higher cost of wheat makes this less economical than maize for the fattening of pigs.

Pigs of mixed ancestry, such as many of those in the Iringa District, are unsuited for bacon production because the resulting carcasses are too fat.

ACKNOWLEDGMENTS.

It is with great pleasure that we acknowledge our indebtedness to Mr. A. Hauter, of Dabaga, who kindly allowed this experiment to be carried out on his farm, and who supervised the feeding of the pigs. We are also grateful for the help and facilities given by the Mtitu Bacon Factory, on whose premises the carcass tests were carried out.

A Useful Hedge Plant (*Pithecolobium Dulce*)

By J. ROBERTSON, *B.Sc. (Agr.), A.I.C.T.A., Agricultural Officer, Tanganyika.*

The success of *Pithecolobium dulce* as a hedge plant at the Mpanganya Agricultural Station has prompted this note, in the hope that this very useful plant may receive wider attention. The hedge was planted in 1930 in order to make the rice fields safe from the depredations of hippopotamus, and the venture has been very successful.

At first, seed was sown in the nursery, the seedlings being planted out on reaching a height of three to four inches. Later, equally good results were obtained by sowing single seeds in the field, four inches apart, and refilling as necessary. The hedge is a single row one, but trials are being made on the double row principle. The plants are very easy to raise, and no difficulty was experienced in obtaining a uniform growth.

The hedge has been established now for six years, and after being cut back once, early last year, to a height of six feet, now ranges from twelve to fifteen feet high. Such vigorous growth would not be produced with the drier conditions and less fertile soil obtaining inland, and, moreover, less vigorous growth would be preferable.

The hedge has been eminently successful not only against hippopotamus but other forms of game as well, various members of the Tanganyika Game Department expressing the opinion that it is proof against all comers with the exception of elephant and rhinoceros. The fact that it is impenetrable to wild pig and wart-hog, as well as unclimbable by baboon and monkey, should make it particularly valuable in the hill lands of the coastal belt, where these pests do so much damage to crops. In these parts also, if planted on the contour, it would be invaluable against soil erosion.

The system of paddocking of grazing land is still in its infancy in East Africa, but since it increases the carrying capacity of the land many-fold, it is bound to become more widely used. At the lower elevations, *P. dulce* should be very useful for this purpose.

A further advantage for rice-growing areas is that the trees seem to thrive equally well in dry and waterlogged soil; in fact, due to the record floods experienced this year, the rice fields were flooded for at least three months without any apparent detriment to the hedge.

Finally, the fact that the trunk and branches are thorny has made the hedge immune to cutting by natives—a form of damage that has been the undoing of many otherwise successful hedges.